Operational Phase Monitoring of Threatened Flora Translocations, In-situ Threatened Plants and Slender Marsdenia and Woolls' Tylophora Habitat Condition on the Warrell Creek to Nambucca Heads Highway Project – Year 5 (2022)

Prepared by:

ECOS Environmental Pty Ltd

PO Box 641 Mullumbimby, NSW 2482

ph 0487050005; andrewbenwell@bigpond.com

Prepared for:

Sandpiper Ecological Surveys

PO Box 401, Alstonville 2477

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Executive Summary

The Warrell Creek to Nambucca Heads (WC2NH) project is a 19.6 km section of the Pacific Highway upgrade on the NSW Mid North Coast. Construction of the project began in February 2015 and it was opened to traffic in July 2018. The project's Threatened Flora Management Plan (RMS 2016) set out measures designed to minimise impacts on threatened flora during highway construction and operation, including (i) threatened flora translocation (ii) protection of in-situ threatened flora populations within the road reserve, (iii) maintaining Slender Marsdenia and Woolls' Tylophora habitat in good condition, and (iv) a monitoring program and annual monitoring report to assess the effectiveness of threatened flora management measures.

This annual threatened flora monitoring report describes the fifth and final year of operational phase monitoring carried out in December 2022. Monitoring has been carried out for a total of approximately eight years, including three years during the construction phase.

Five threatened and one rare plants species impacted by the project were translocated to nine recipient sites located in the road reserve within the WC2NH project boundary: -

- Slender Marsdenia (*Marsdenia longiloba*) (listed as endangered under the *Biodiversity Conservation (BC) Act 2016* and vulnerable under the *Environment Protection and Biodiversity Conservation (EPBC) Act 1999*)
- Woolls' Tylophora (*Tylophora woollsii*) (listed as endangered under the BC Act and the EPBC Act)
- Rusty Plum (*Niemeyera whitei*) (listed as vulnerable under the BC Act)
- Spider Orchid (*Dendrobium melaleucaphilum*) (listed as endangered under the BC Act)
- Floyds Grass (*Alexfloydia repens*) (listed as endangered under the BC Act)
- Koala Bells (*Artanema fimbriatum*) (nationally rare and proposed for State listing).

The translocations were carried out by transplanting impacted plants. Survival rates of the five threatened species in 2022 eight years after translocation were as follows: Slender Marsdenia 55%, Woolls' Tylophora (17%), Spider Orchid 100%, Rusty Plum 86% and Floyds Grass (small amount remaining). Koala Bells had already died out and no new plants appeared (Table 1). The translocation project generated new information on the translocation response, population dynamics and ecology of Slender Marsdenia and the other species, as described in this report.

Table 1: Percent survival of five threatened and one rare species translocated to nine recipient sites after 8 years (2015-2022)

Species/Recipient Sites	Number Translocated	Survival (%) after 8 years (to Dec 2022)
Slender Marsdenia		
Recipient Site 1 - Cockburns Lane	27	74
Recipient Site 2 (3) – Old Coast Rd	17	82
Recipient Site 3 (5a) – Old Coast Rd	22	57
*Recipient Site 4 (5b) – Old Coast Rd	10	60
Recipient Site 5 (7a) – Old Coast Rd	57	39
Recipient Site 6 (8a) – Old Coast Rd	8	50
Recipient Site 8 (8c) – Old Coast Rd	28	52
Total/All Sites	163	55

Species/Recipient Sites	Number Translocated	Survival (%) after 8 years (to Dec 2022)
Woolls Tylophora		
Recipient Site 6 (8a) – Old Coast Rd	6	17
Rusty Plum		
Recipient Site 1 - Cockburns Lane	7	86
Spider Orchid		
Recipient Site 5 (7a) – Old Coast Rd	2	100
Floyds Grass		
Recipient Site 9a – Warrell Creek	54 clumps	Small cover-abundance
Recipient Site 9b – Warrell Creek	61 clumps	Small cover-cover abundance
Koala Bells		
Recipient Site 7 (8b) – Old Coast Rd	16	0
Recipient Site 9 – Warrell Creek	14	0

* Note – Site 5b included 6 *Marsdenia liisae* (rare, not a threatened species) and 10 *M. longiloba*

In-situ threatened plants in the WC2NH road reserve maintained satisfactory survival rates at the end of Year 8. Spider Orchid, and Rusty Plum were 100%, although the condition of the two Spider Orchid clumps had declined, as observed in the translocated clumps. The small Rusty Plum trees were in good condition, and some fruited during the eight year monitoring period. The stand of in situ Maundia on the Nambucca River floodplain declined from 40% crown-cover in 2018 to <1% at the peak of the drought in 2019. In 2020 after the drought broke, Maundia recovered to about 20% crown-cover, 40% by late 2021 and over 50% in 2022, returning to its pre-drought abundance. All in situ Slender Marsdenia were small plants (<1 m high) and most died back and reshot during the monitoring period, as recorded for many small transplanted stem-individuals. Koala Bells plants appeared spontaneously at one location in the road reserve of Old Coast Road in 2021 and persisted in 2022.

Threatened flora habitat condition

The monitoring plot data found no evidence of declines in Slender Marsdenia or Woolls' Tylophora habitat condition along the edge of clearing next to the new highway.

1 Introduction

The Warrell Creek to Nambucca Heads (WC2NH) project is a 19.6 km section of the Pacific Highway upgrade on the NSW Mid North Coast (Figure 1). Construction of the WC2NH project began in February 2015 and the new section of highway was opened to traffic (i.e. operational) in July 2018.

A Threatened Flora Management Plan was prepared for the WC2NH project (RMS 2016 updated), which included a monitoring program aimed at documenting and assessing three sets of measures designed to manage threatened flora recorded within the WC2NH project boundary: (i) threatened flora translocation (ii) protection of in-situ threatened flora populations within the road reserve, and (iii) maintaining Slender Marsdenia habitat in good condition. These measures were monitored during construction and operation of the project.

This annual threatened flora monitoring report describes the fifth and final year of operational phase monitoring carried out in December 2022. Results of construction phase monitoring are described in Ecos Environmental (2016), Ecos Environmental (2017) and Ecos Environmental (2018a), and previous operational phase monitoring in Ecos Environmental (2018b), Ecos Environmental (2019), Ecos Environmental (2020) and Ecos Environmental (2021). Results for the current annual monitoring period (Year 8) are described and discussed in the following sections below:-

- Section 2: Threatened Flora Translocations
- Section 3: In-situ Threatened Flora Populations
- Section 4: Slender Marsdenia and Woolls' Tylophora Habitat Condition.

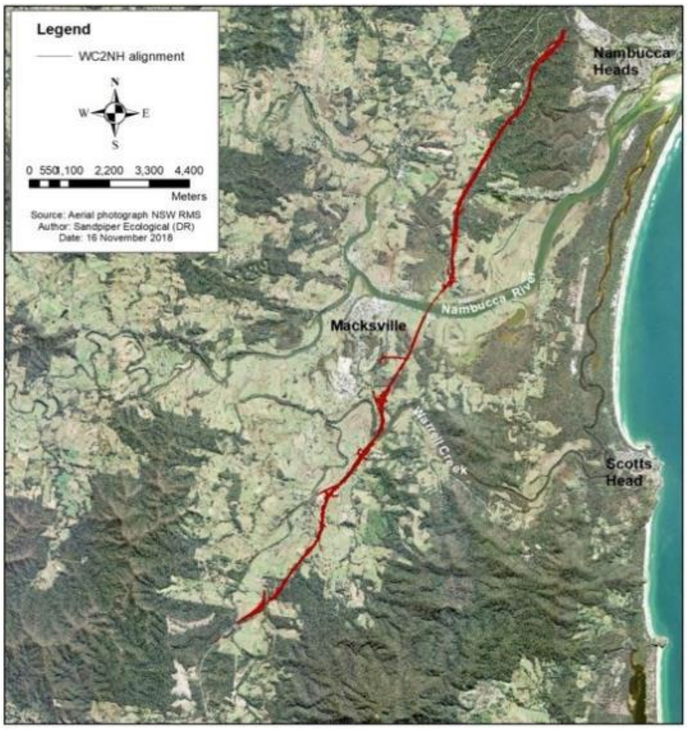

Figure 1: Location of the WC2NH Pacific Highway upgrade.

2 Threatened Flora Translocation

2.1 Aim and Species Translocated

The translocation component of the Threatened Flora Management Plan (TFMP) is described in detail in the section containing the Translocation Plan. The format and content of the Translocation Plan generally follows ANPC (2004), *Guidelines for Planning Threatened Flora Translocations in Australia*

The aims of threatened flora translocation for the WC2NH project were:

- to maintain population size of threatened species and avoid loss of population due to direct or indirect impacts of highway construction.

- to rescue and re-establish individuals of threatened species impacted by construction in suitable habitat within the project boundary.

Translocation involved three main actions:

- Rescue or salvage transplanting of impacted individuals and their re-establishment at recipient sites containing habitat closely approximating the impacted/donor sites;
- Propagation and introduction of additional individuals as back-up in case of losses; and
- Follow-up maintenance to promote successful establishment and ensure habitat remains in good condition.

Five threatened and one nationally rare plant species were translocated on the WC2NH project:

- Slender Marsdenia (*Marsdenia longiloba*) (listed as endangered under the *BC Act* and vulnerable under the *EPBC Act*)
- Woolls' Tylophora (*Tylophora woollsii*) (listed as endangered under the *BC Act* and the *EPBC Act*)
- Rusty Plum (*Niemeyera whitei*) (listed as vulnerable under the *BC Act*)
- Spider Orchid (*Dendrobium melaleucaphilum*) (listed as endangered under the *BC Act*)
- Floyds Grass (*Alexfloydia repens*) (listed as endangered under the *BC Act*)
- Koala Bells (*Artanema fimbriatum*) (nationally rare and has been proposed for State listing).

A sixth threatened species, *Maundia triglochinoides* was also translocated, although not required by RMS (2016).

2.2 Methods

2.2.1 Recipient Sites

Nine recipient sites located in the highway road reserve were selected for re-establishing threatened species moved from the highway construction footprint. Seven recipient sites are in the section of highway corridor where it crosses Nambucca State Forest, one site is near the new highway bridge over Warrell Creek, and one near the southern end of the project

(Table 1 and Figure 2). Further details of recipient site selection and site descriptions are provided in Ecos Environmental 2016, 2017 and 2018a.

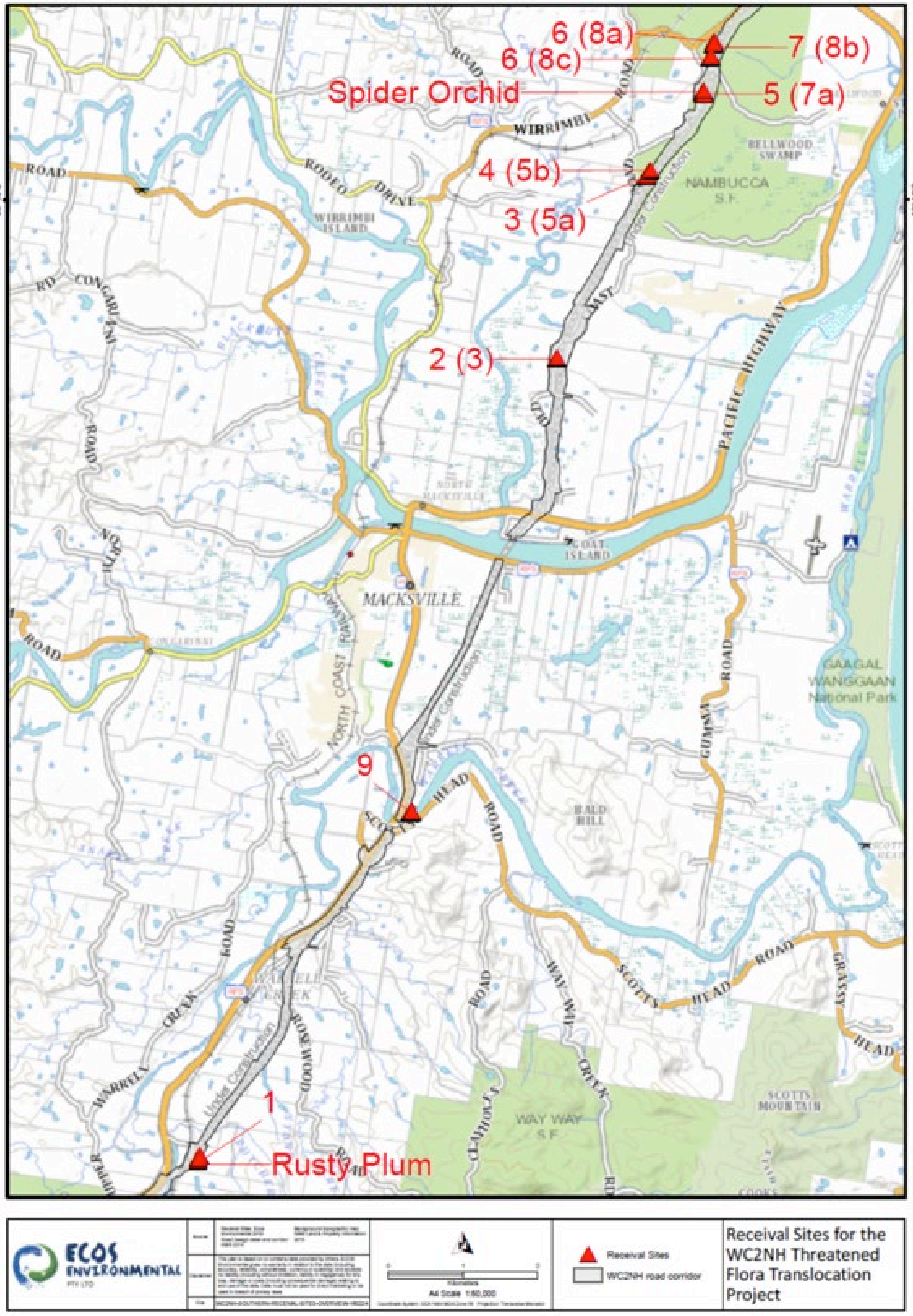

Figure 2: Location of threatened flora translocation recipient sites on the Warrell Creek to Nambucca Heads (WC2NH) project.

Table 1: Translocation recipient sites and species translocated to each site. A question mark after Woolls' Tylophora indicates that identification of this species was not confirmed (i.e. based on leaves, not flowers). The bracketed number is the original site identifier used during the selection process.

Recipient Site	**Species**
1 (Cockburns Lane)	Slender Marsdenia, Rusty Plum
2 (3)	Slender Marsdenia
3 (5a)	Slender Marsdenia
4 (5b)	Slender Marsdenia (and Large-flowered Marsdenia)
5 (7a)	Slender Marsdenia, Spider Orchid, Rusty Plum direct seeding, Slender Marsdenia population enhancement.
6 (8a)	Slender Marsdenia, Woolls' Tylophora(?)
7 (8b)	Koala Bells
8 (8c)	Slender Marsdenia
9 (Warrell Creek)	Floyds Grass, Koala Bells population enhancement

2.2.2 Direct Transplanting

Threatened species were translocated from the construction footprint using the direct transplanting method. This involves excavation, transport to the recipient site and replanting as a single operation, which is carried out as quickly as practical to minimise stress on plants. Trees and saplings are removed using an excavator or back-hoe and small plants with hand tools. The method entails excavation of a substantial amount of the root system in in a soil-root ball and pruning of the shoot system to reduce evapotranspiration stress.

Direct transplanting may have advantages over other translocation methods such as propagation and gradual excavation (i.e. trenching and root pruning), including:

1. Transplanted mature plants produce flowers and seed sooner and in greater quantity than propagated plants.
2. A short period of physiological stress during transplanting is better for survival and healthy growth than a prolonged period of stress using other methods.
3. Reduces risk of transferring microbial pathogens from a nursery environment, or in extraneous materials (e.g. soil ameliorants), to the translocated plants or soil at the recipient site.
4. Naturally occurring mycorrhizae and soil microflora which are important for natural, healthy growth are maintained by moving plant and soil together.
5. Method is practical for translocating large numbers of small to medium size individuals and limited numbers of large individuals.
6. Cost-effective.

Primack (1996) pointed out other advantages: - "There are nonetheless ecological advantages to using transplanted plants rather than seeds in reintroduction (translocation) efforts. Plants, particularly adult plants have a higher likelihood of successful establishment than seeds (or seedlings) if they are planted into a suitable site and well-tended. These plants have overcome the most vulnerable stages in their life cycle (seed germination and seedling establishment) so that their chances of surviving in the new habitat are greatly increased. These individuals also have proven genotypes that are free of lethal mutations and adapted to the general environmental conditions. When reintroduction efforts involve reproductively mature adult plants, the new population has the potential to flower, produce and disperse seeds and create a second generation of plants within a year (or so) of transplantation".

2.2.3 Slender Marsdenia

2.2.3.1 Plant Rescue - Salvage Transplanting

Transplanting of Slender Marsdenia from the construction footprint to seven recipient sites was carried out in February 2015 (Table 1). The recipient sites were located near the donor sites to maintain roughly the original distribution. Stem and root system were moved in small slabs of soil approximately 30 cm x 30 cm x 20 cm in depth. Transplanting retained some of the original root system including rhizomatous roots. The original extent of rhizomes and the root system is unknown.

Plants and soil were kept damp during transport and watered as soon as they were planted. The ‘stem-individuals’ were planted at 5 m intervals along lines to reduce potential bias in selecting planting points, and also to facilitate monitoring. Additional plants were translocated in 2016 due to a modification in the road design. In total, 163 stem-individuals were translocated.

The transplants were watered once every two days for the first week then once a week for four weeks. Chicken wire cylinders (90 cm high) were installed to prevent animal digging and grazing, to act as a climbing frame and to facilitate monitoring. Flagging tape was attached to the base of each stem just above the ground for checking if stems that had died back were still alive. Flagging tape with a monitoring number and the plant’s source code as per the translocation plan (TFMP) was attached to each cage. Where there was more than one stem-individual at a mapped/donor point, the stem individuals were indicated by numbers added to the original plant source code e.g. ML 46-6, ML46-7.

2.2.3.2 No Fertiliser

As translocation of Slender Marsdenia on the Bonville Project south of Coffs Harbour (Ecos Environmental 2016) found slow-release fertiliser appeared to adversely affect the survival of transplanted Slender Marsdenia. This could be due to the fertiliser leaching out of the pots and not remaining in the soil in proximity to the root zone. In the field it could remain in the soil and available for uptake for longer periods, in higher concentration. No fertilisers or mulch were applied during the WC2NH translocation of this species. (Note – on the NH2U project, a translocation trial was designed to compare fertiliser and no fertiliser treatments on Slender Marsdenia, as well as other variables. The fertiliser treatment was very light but still appeared to decrease growth (Ecos Environmental 2016). Unfortunately, the writer was unable to continue the experiment as another consultant was appointed.

2.2.3.3 Propagation of Population Enhancement Plants

Propagation of Slender Marsdenia was attempted from rhizome pieces that broke off during transplanting. The strike rate of rhizome cuttings was <5% and the growth rate of cuttings that struck was very slow. The same result for attempted rhizome propagation was recorded on the NH2U project. The few propagated plants on WC2NH were grown-on for two years and planted out in November 2017 at Recipient Site 7a. (Note – although this species in the wild appears to reproduce vegetatively by producing shoots from its thin tuberous rhizomes, these stem shoots are not common. The poor results of propagation from root cuttings in a nursey, suggest this form of reproduction does not play a major role in increasing population number in the wild.)

With the aim of propagating more plants from seed, searches for seed pods of Slender Marsdenia were carried out in December 2016, focusing on locations of large plants previously recorded by the author on the WC2NH, NH2U, Bonville and S2W sections of the Pacific highway, but no pods were found. A single pod was found in summer 2014/2015 during pre-construction flora surveys for the WC2NH project near the southern boundary of the NH2U project. The pod contained about 100 seeds which had a high germination rate. The seedlings were used in a translocation experiment on the NH2U project (Ecos Environmental 2016).

2.2.4 Woolls' Tylophora

2.2.4.1 Species Identification

Woolls' Tylophora has not been positively identified on the WC2NH project, as no flowering plants have been found. A few plants were tentatively identified as Woolls' Tylophora during pre-construction surveys, based on leaf features. This species is very similar vegetatively to Slender Marsdenia, although it has very different flowers. Typically, Slender Marsdenia has a more elongated leaf, pinnate venation, cordate leaf base and is glabrous (without hairs). Woolls' Tylophora has a broader leaf with purplish tinges (not always), tends to be more 3-veined at the base and is sparsely hairy (hand lens needed). The two species flower locally at different times - Woolls' Tylophora flowered on the Bonville project in late August, whereas Slender Marsdenia flowered in November or occasionally later (pers. obs.).

2.2.4.2 Salvage Transplanting

Individuals tentatively identified as Woolls' Tylophora were transplanted using the same methods applied to Slender Marsdenia. Both species are vines with tuberous roots. Woolls' Tylophora was translocated to Recipient Site 8a, which also received Slender Marsdenia (Table 1).

2.2.5 Rusty Plum

2.2.5.1 Transplanting

Rusty Plum occurred on the footprint in the Cockburn's Lane section at the southern end of the project. Rescued plants were transplanted into the adjacent road reserve at Recipient Site 1, also used for Slender Marsdenia. An excavator was used to trench around two Rusty Plum trees about 12 m high, forming a soil-root ball about 0.7 m deep and 1-1.5 m wide. The vibration of the excavator carrying the trees caused the root ball to fall apart, so the trees were transplanted bare-rooted and trunks were cut off 1-1.5 m above the ground. This prevented evapotranspiration stress and re-balanced the root-stem system.

Transplanted trees and saplings were watered for about one month by the construction contractor. Sugar cane mulch was spread around each plant. Hessian screening was erected to reduce exposure to the afternoon sun. No fertilisers were used. Several Rusty Plums remained in-situ within the project boundary next to the construction footprint.

2.2.5.2 Population Enhancement by Direct Seeding

To enhance population size, a trial introduction of Rusty Plum by direct seeding was carried out at Recipient Site 7(a), using 50 fruits collected in Nambucca State Forest in November 2017. The outer fleshy layer of each fruit was removed and the single, golf-ball sized seed planted in leaf litter on the 7th December 2017. The introduction site is in a minor gully supporting Flooded Gum wet sclerophyll forest with a mesic understorey. Seeds were placed inside metal mesh cylinders held in place with a wooden stake, because in a similar direct seeding trial on the NH2U project, seeds were taken by animals and germinated seedlings heavily browsed (Ecos Environmental 2015). Fourteen cylinders were set out and three seeds placed in each cylinder and lightly covered with leaf litter. The cylinders were tagged for monitoring and locations recorded with a GPS.

2.2.6 Spider Orchid

2.2.6.1 Transplanting

Two clumps of Spider Orchid growing on the branches of Prickly Paperbark (*Melaleuca styphelioides*) were rescued from the WC2NH footprint. A section of branch about 0.8 m long was sawn off so the orchids were moved with minimal root disturbance. The branch was tied onto the trunk of a small tree in a shaded gully at Recipient Site 7a. Plants were watered during transport, but no further watering was carried out after introduction to the site.

The Spider Orchid clumps flowered in September each year from 2015 to 2022, but no seed pods were produced. At the November-December monitoring, shrivelled up floral axes at the apex of pseudobulbs indicated that flowering had occurred and there was no evidence of the seed pod which is about 5 cm long. In-situ plants were also monitored and flowers, but no seed pods recorded. Many flowers were produced in each clump, so it appears the flowers require cross-pollination by an insect that was absent from the translocation site.

The orchid clumps declined in size (number of pseudobulbs) between 2020 and 2022. As observed with the in-situ plants, pseudo-bulbs were being grazed, stripping off the surface green tissue layer and hollowed out, probably by an insect or mollusc. A few new pseudobulb shoots were present in 2021 and 2022, compared to many in previous years. Decline may have been due solely to the grazer, or the branch substrate may have been supplying less nutrient. More than half the pseudobulbs in each clump flowered in 2022, so they must still be in reasonable condition, despite grazing.

2.2.6.2 Population Enhancement

The WC2NH threatened flora management plan proposed to propagate Spider Orchid for introduction to enhance the local population of this species. Vegetative propagation by division of clumps was not a suitable option due to the rarity of wild plants. Propagation from seed was possible and a propagator was organised of known Spider Orchid locations at previously observed seeding time (see below) failed to find any seed pods.

On the NH2U project, one pod was produced in a translocated population of 55 Spider Orchids. Unfortunately, the pod opened between site visits in November 2016 and the seeds dispersed before they could be collected for propagation.

2.2.7 Koala Bells

2.2.7.1 Salvage Transplanting

Koala Bells was transplanted in blocks of soil 40 cm wide by 20 cm deep. Plants were pruned and the soil block planted at Recipient Site 8b, which was the only site in the WC2NH road reserve with swamp forest similar to Koala Bells habitat. Wire cylinders were installed around the plants and follow-up watering carried out. No fertilisers were applied.

2.2.7.2 Population Enhancement

Cuttings of Koala Bells were propagated at Ecos Environmental's nursery in summer 2015-2016. The cuttings formed roots and flowered over summer-autumn 2016, died back in winter then reshot in spring 2016, while still in pots. Regrowth in spring 2016 was less vigorous and small adventitious shoots (vegetative reproduction) were produced around the edge of the pots. (Vegetative reproduction was also observed in some transplants in the field on NH2U.) Twenty plants were introduced to Recipient Site 9b (Floyds Grass translocation site) at Warrell Creek in January 2017. This site had alluvial soil and an open ground layer with little competition.

2.2.8 Floyds Grass

2.2.8.1 Removal of topsoil containing weed seedbank

Floyds Grass was introduced to two 20 m x 20 m areas about 30 m apart located on the northern side of Warrell Creek (Recipient Sites 9a & 9b), 50-100 m from the donor site at the highway bridge over Warrell Creek. The soil type was clay alluvium suitable for Floyds Grass but the vegetation was very weedy, being dominated by Broad-leaved Paspalum (BLP) and Lantana.

A novel grass-topsoil stripping procedure was carried out to prepare the site for introduction of Floyds Grass. As the site appeared to be on deep alluvium, it was assumed there would be sufficient depth of alluvial topsoil left after the stripping operation. The other alternative was to spray out weeds with herbicide, but they were likely to regrow from the soil seedbank and follow-up spraying would be difficult without hitting Floyds Grass, which spreads by surface runners. The strategy was therefore to physically remove BLP and topsoil containing its seedbank, then plant Floyds Grass into a weed-free site.

Preparation of the site was carried out as follows. Firstly, BLP and Lantana were scrapped off with an excavator bucket. After exposing the soil surface, the top 10 cm of soil was also scrapped off. The soil beneath the uppermost 10 cm had a higher clay content, but soil texture and drainage still reasonable for plant growth. Sed fencing was installed around the site to prevent sediment run-off into Warrell Creek and to deter wallaby grazing.

2.2.8.2 Transplanting

Small clumps of Floyds Grass growing on the edge of Warrell Creek at the bridge site were dug out with a spade and planted into Recipient Site 9a. The plants were watered, and sugar cane mulch (weed free) spread lightly to reduce raindrop compaction. Follow-up watering was carried out as conditions were dry. 'Seasol fertiliser was applied two weeks after introduction to stimulate growth. As the site was exposed to the afternoon sun, 1 m high shade-cloth fences were erected to provide additional shade. These were removed in 2021.

Although the topsoil seedbank had been removed, seed germinated from deeper in the soil, notably *Phytolacca octandra* (Ink Weed), a large herbaceous shrub, but there was very little BLP germination.

2.2.8.3 Population Enhancement

To increase the size of the salvaged population, approximately 100 Floyds Grass were propagated at Ecos Environmental's nursery and planted in Recipient Site 9b in March 2016. Plants were propagated from small pieces of runner (stolons) that broke off during transplanting. As site 9b was more exposed than site 9a, the shade cloth fences had an awning to protect from the overhead sun. Follow-up hand weeding to remove exotic and native species was carried out.

2.2.9 Monitoring and Data Analysis

Monitoring of the translocations was carried out quarterly for the first year, six monthly for the second year and once a year thereafter, including operational phase monitoring from 2018 to 2022.

The following data were recorded to assess survival and growth:

- All species except Spider Orchid: Monitoring Number, Date, Line, Source Label (species translocation plant label), Species (Current ID), Overall Condition (see below), Height (cm), New Shoots (Y/N), Comments, Significant Growth (+) or Significant Dieback (-), Coordinates.

- Spider Orchid: Monitoring Number, Date, Source Label, Species, Number of Pseudobulbs with Leaves, Length of the Longest Pseudobulb, New growth, Overall Condition, Coordinates.

Plant condition was scored on a scale of 0 to 5, where zero = dead and 5 = fully mature, reproductive (Table 2-4).

Floyds Grass crown cover was measured by visual assessment of crown cover in metres squared.

Slender Marsdenia individuals that died back to the ground were scored as 1 rather than 0 (dead) because new stems were often produced, regrowing from the root crown. Plants with above ground stem growth (i.e. condition score of 2 or higher) were included in the calculation of % survival.

Percent survival of Slender Marsdenia = no. number of plants in condition classes 2+3+4+5/total number x 100; or number of plants with height >0/total number of plants x 100.

Mean plant height was used as a measure of how well Slender Marsdenia performed at each recipient site after translocation. Mean height was calculated by averaging across all individuals, including those with zero height (i.e. condition class 1 or 0). In effect, this provided an approximate measure species performance weighted by number of mortalities.

The relationship between the mean height of Slender Marsdenia and openness of understorey habitat was examined using linear regression. The relative openness and light intensity in understorey habitat at the recipient sites was scored on a scale of 1 to 3, as follows:-

1 = dense (i.e. understorey habitat more shaded due to a more well-developed rainforest component in the mid to lower strata);
2 = medium (i.e. understorey habitat somewhat more open - between 1 and 2)
3 = open (i.e. understorey habitat relatively open, exposed to breezes, rainforest elements sparse, higher light level in the understorey).

Linear regression examined if a significant relationship existed between Mean Height, Habitat Openness and Survivorship, using Excel.

Table 2: Condition scores applied to Slender Marsdenia and Woolls' Tylophora.

Score	Condition
0 – dead	Dead, no sign of reshooting 2 years after dying back
1 –poor	Stem died back to ground level, possibly dead, live stem stub may be present
2 – fair	Plant <75 cm tall, with leaves or leafless, new shoots or active growth present or absent
3 – good	Plant >75 cm tall, stem with leaves, new shoots or active growth present or absent, if stem leafless or leaves discoloured score as 2
4 – advanced	Plant >2.5m tall with >15 leaves
5 – mature	Mature, plant flowering or seeding

Table 3: Condition scores applied to Rusty Plum and Koala Bells.

Score	Condition
0	Dead
1	Leafless and no sign of re-shooting
2	Pruned foliage retained, or small amount of re-shooting after defoliating, or foliage sparse/discoloured (<40 cm tall for Koala Bells)
3	Vigorous re-shooting (>40 cm tall for Koala Bells)
4	Crown recovering, foliage healthy
5	Growing actively, flowering or seeding recorded

Table 4: Condition scores applied to Spider Orchid.

Score	Condition
0	Dead

1	Pseudobulbs discoloured or grazed or withering, no new growth
2	Pseudobulbs healthy in colour, not withering, no new growth
3	Plant small, few healthy pseudobulbs, new growth occurring
4	Several healthy pseudobulbs present, new growth occurring
5	Several good sized, healthy pseudobulbs, flowering or seeding recorded

2.3.10 Analysing stem growth phenology in Slender Marsdenia

Slender Marsdenia showed a wide range of response to translocation in terms of stem regrowth. Temporal patterns of stem growth in translocated Slender Marsdenia were classified into different categories of stem height change over eight years. These were derived by examining stem height data over 8 years in a spreadsheet and identifying characteristic syndromes of height change in the 163 stem individuals (Table 5).

Stem height change pattern was allocated to three primary categories: (i) 'D' - stem height zero, recorded 2022 (i.e. most of these plants were probably dead, but some may reshoot); (ii) 'S' - small stem-individual (i.e. little height growth over eight years); and (iii) 'T' - stem-individual tall (i.e. relatively vigorous height growth). Individuals in the primary categories were then allocated to four sub-categories as defined in Table 5.

Individuals showing one or more cycles of stem dieback to ground level then reshooting over 8 years, referred to as oscillations, were recorded along with the number of oscillations in eight years. (Note – a decrease in height to zero at the last monitoring (i.e. category D) was not counted as an oscillation as the plant had to regrow again to be a full oscillation.)

Numbers of individuals in each category were tallied and expressed as percentages of the total number of stems at each recipient site.

Table 5: Categorisation of response of Slender Marsdenia to translocation in terms of stem growth phenology over 8 years. Individuals were placed in three primary categories: ‘D’ stem height zero; the majority of these plants were probably dead, some may reshoot; ‘S’ stem-individual small, little height growth over eight years; and ‘T’ stem-individual tall, relatively vigorous height growth. Primary categories were divided into four sub-categories as shown below. Those with “(O)” indicate some stems oscillated in stem height, having one or more cycles of stem dieback to ground level then reshooting.

Code	Response syndromes of transplanted individuals (outcome after 8 years)
D	**Stem height zero at last monitoring in Dec/2022; plant died back to ground; may be dead or may reshoot**
D1	Never reshot
D2	Small shoot for one or more years then died back to ground, probably dead
D3 (O)	Reshot, reached small (<10 cm) to medium height (<1.2 m) then died back to ground, some fluctuated (i.e. dieback-reshoot-dieback)
D4 (O)	Reshot, grew tall (~2 m+) then died back to ground, some fluctuated, probably dead
S	**Small, growing very slowly, or declining**
S1	Stayed small, mostly less than 10 cm high, occasionally to 50 cm, little change in height in 8 years
S2 (O)	Died back to ground and reshot once or twice, continuously small (mostly <50 cm)
S3	Declining or bell shaped (increase-decrease), some to ~130cm at peak, continuously alive but stem mostly small (<50 cm)
S4 (O)	Fluctuating – e.g. ‘small-medium/tall-small’; or ‘grew medium/tall then died back to small
T	**Thriving, plant relatively tall, continuing to grow, or maintaining size, healthy**
T1	Tall (1.5 m+), substantial increase in height/number of leaves, or maintained tall height
T2	Moderately tall (0.75 – 1.5 m +), moderate increase in height (0.5 m to 1 m or more), or height constant
T3 (O)	Died back to ground then reshot vigorously (>1 m)
T4	Small for several monitoring events then suddenly grew taller (>1 m)

2.3 Translocation Results

2.3.1 Species Survival Summary

Survival rates of the five translocated threatened species after eight years were as follows: Slender Marsdenia 55%, Woolls' Tylophora (17%), Spider Orchid 100%, Rusty Plum 86% and Floyds Grass (small amount remaining) (see Table 6). Koala Bells had already died out and no new plants appeared.

Slender Marsdenia survival decreased from 68% in 2021 to 55% in 2022. Woolls' Tylophora continued to decrease to 17% in 2022. Only a small cover of Floyds Grass remained in terms of crown cover. Spider Orchid percent survival was constant. Rusty Plum maintained survival and relatively good condition. Further details below.

Table 6: Survivorship (percent) of five threatened and one rare species translocated to eight recipient sites over 8 years (2015-2022)

		Time since translocation/Survivorship (%)							
Recipient Site	**No.**	**Aug 2015 (6 mth)**	**Jan 2017 (2 Yrs)**	**Nov 2017 (3 Yrs)**	**Nov 2018 (4 Yrs)**	**Nov 2019 (5 Yrs)**	**Nov 2020 (6 Yrs)**	**Nov 2021 (7 Yrs)**	**Dec 2022 (8 Yrs)**
Slender Marsdenia(*Marsdenia longiloba*)									
Recipient Site 1 - Cockburns Lane	27	93	75	63	59	59	56	78	74
Recipient Site 2 (3) – Old Coast Rd	17	91	93	88	88	88	88	88	82
Recipient Site 3 (5a) – Old Coast Rd	22	81	91	73	77	68	68	77	57
*Recipient Site 4 (5b) – Old Coast Rd	10	94	81	69	69	50	71-	75	60
Recipient Site 5 (7a) – Old Coast Rd	57	90	72	71.5	72	56	61	53	39
Recipient Site 6 (8a) – Old Coast Rd	8	75	75	75	88	86	93	75	50
Recipient Site 8 (8c) – Old Coast Rd	28	100	86	82	79	70	67	59	52
Total/All Sites	163	91	80	74	74	68	68	68	55
Wooll's Tylophora (*Tylophora woollsii* – unconfirmed)									
Recipient Site 6 (8a) – Old Coast Rd	6	100	100	83	67	67	67	33	17
Rusty Plum(*Niemeyera whitei*)									
Recipient Site 1 - Cockburns Lane	7	100	86	86	86	86	86	86	86
Spider Orchid (*Dendrobium melaleucaphilum*)									

		Time since translocation/Survivorship (%)							
Recipient Site	**No.**	**Aug 2015 (6 mth)**	**Jan 2017 (2 Yrs)**	**Nov 2017 (3 Yrs)**	**Nov 2018 (4 Yrs)**	**Nov 2019 (5 Yrs)**	**Nov 2020 (6 Yrs)**	**Nov 2021 (7 Yrs)**	**Dec 2022 (8 Yrs)**
Recipient Site 5 (7a) – Old Coast Rd	2	100	100	100	100	100	100	100	100
Floyds Grass (*Alexfloydia repens*)									
Recipient Site 9a – Warrell Creek	54 clumps	94	Substantial cover	Substantial cover	Substantial cover	Substantial cover	Fair cover	Fair cover	Small cover
Recipient Site 9b – Warrell Creek	61 clumps	Not planted yet	98	93	70	Reasonable cover	Fair cover	Fair cover	Small cover
Koala Bells (*Artanema fimbriatum*)									
Recipient Site 7 (8b) – Old Coast Rd	16	63	25	13	6	0	0	0	0
Recipient Site 9 – Warrell Creek	14	Not planted yet	Not yet planted	57	86	75	0	0	0

* Note – Site 5b included six *Marsdenia liisae* (a rare, not threatened species) and ten *M. longiloba*.

2.3.2 Slender Marsdenia (*Marsdenia longiloba*)

2.3.2.1 Survival rate

The survival rate of Slender Marsdenia after eight years was 55%, a decline of 13% since last year. Decrease in survival was more pronounced at Sites 5a, 7a and 8a, and less at Sites 1, 3 and 8c (Table 6).

Three individuals flowered in 2022 compared to only one individual in all previous years.

2.3.2.2 Change in mean height per recipient site

In 2021-2022, mean stem height decreased in five sites and increased in one site (Site 1) (Figure 3). However, from inspection of Figure 3 it appears there was little synchronisation between sites in the pattern of stem growth over 8 years. In a given year, it was common for mean height to increase in some sites and decrease in others. (Figure 3).

Mean height of Slender Marsdenia per site after eight years ranged from 32.6 cm to 127.9 cm (Table 7), which suggested that height growth was affected by differences in one or more habitat variables which vary between sites.

In sites 5a and 7a, after increasing in the first year, mean height did not change much for five years (Figure 3). In sites 1 and 8c, there was a small to moderate increase in mean height, and in sites 3 and 8a, a large increase in mean height then a decline in mean height in 8a in the last two years (Table 7). Possible reasons for different patterns of mean height change include:

- Variation in understorey light intensity or other fine-scale, microhabitat differences between recipient sites (note - landscape-scale habitat variables such as vegetation type, soil type and topography were relatively uniform across sites).
- Differences in the plants introduced to each site.
- Herbicide spray drift from maintenance of the watermain easement track may have affected Site 8a.

Mean height of Slender Marsdenia tended to be lower at recipient sites with a more shaded understorey. Leaf size was also often smaller in the latter habitat. Linear regression indicated a statistically significant relationship between mean height and understorey openness amongst the recipient sites ($R^2 = 0.75$; $F = 16.32$; $p = 0.01$). Removing site 8a, which appeared to be affected by spray drift, R^2 increased to 0.93. However, there was no relationship between survivorship and mean height, or between survivorship and understorey openness, which suggested that individuals were able to survive despite relatively low growth rate.

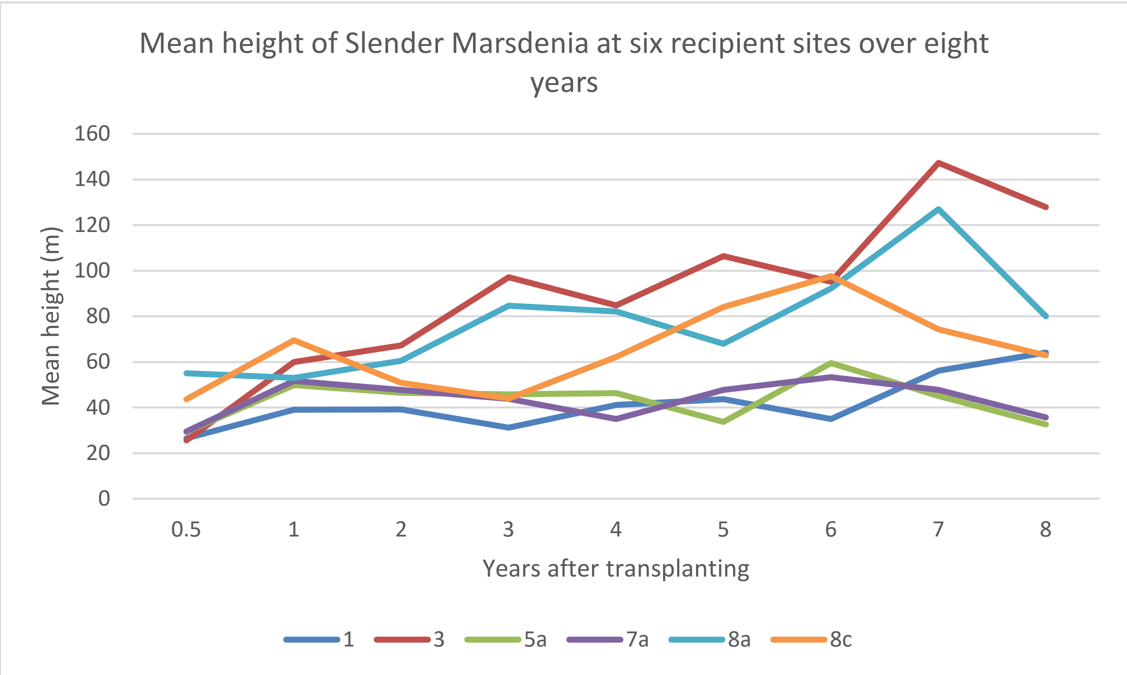

Figure 3: Mean height of Slender Marsdenia at 6 recipient sites between 2015 and 2022.

Table 7: Mean height (cm) ± standard error of Slender Marsdenia at 6 recipient sites from June 2015 to December 2022 (approx. 8 years after translocation). This data is plotted in Fig 3. Decline in mean height this year is party related to decrease in survivorship and more zero's in the height data.

Recipient site	**n**	**June 2015 (0.5 yr)**	**Feb 2016 (~1 yr)**	**Jan 2017 (~2 yrs)**	**Nov 2017 (~3 yrs)**	**Nov 2018 (~4 yrs)**	**Nov 2019 (~5 yrs)**	**Nov 2020 (~6 yrs)**	**Nov 2021 (~7 yrs)**	**Dec 2022 (~8 yrs)**	**Understorey Openness**	**Site Openness/Geology Description**
Recipient Site 1	27	26.5±6.5	39.0±10.4	39.2±10.6	31.1±10.3	41.13±9.5	43.7±8.8	35.0±12.0	56.2±14.60	64.1±20.4	2	Medium, upper slope, sth facing, few big eucalypts, low regrowth wsf /rf on intermediate igneous
Recipient Site 2 (3)	11	25.6±10.1	60.8±15.5	67.3±13.6	97.1±14.2	84.8±12.7	106.4±13.2	95.2±15.9	147.3±23.1	127.9±30.5	3	Open, upper slope, east facing, open forest with open understorey, always breezy; metasediment
Recipient Site 3 (5a)	22	29.3±7.5	49.8±11.2	46.4±9.5	45.7±9.3	46.3±10.8	33.7±9.5	59.5±15.0	45.1±10.5	32.6±12.7	1	Dense, Blackbutt wsf-rainforest lower slope, east facing, thick barky litter; metasediment
Recipient Site 5 (7a)	57	29.5±3.7	51.7±6.9	47.7±7.6	43.8±8.1	35.0±6.3	47.7±5.7	53.3±10.6	47.7±11.5	35.7±9.0	1	Dense, lower slope, south facing, wsf-rainforest; metasediment
Recipient Site 6 (8a)	8	55.1±22.2	53.0±17.9	60.5±17.5	84.7±18.3	82.1±19.1	68.0±17.7	92.2±25.9	126.9±42.6	80.0±46.0	3	Open, next to track and highway (clearing), fairly exposed to north east, lower slope; metasediment
Recipient Site 8 (8c)	27	43.6±6.3	69.5±9.1	50.8±5.9	43.9±5.4	62.2±10.6	84.1±9.6	97.6±26.1	74.2±22.3	62.9±20.1	2	Medium, mid slope, south facing, open forest understorey; metasediment

2.3.2.3 Pattern of stem growth in Slender Marsdenia individuals

Mean height per site provided no indication of how stem growth varied between individuals. within sites. Translocated individuals in fact showed wide variation in degree and timing of stem regrowth. Combining all individuals, after eight years, 45% of individuals were in stem height category D (height=0), 24% in category S (small) and 31% in stem height category T (tall).

Overall, around 40% of stems showed oscillatory stem growth, meaning stems after increasing in height, died back to ground level, then reshot again. Of stems in categories D and S, about half showed oscillatory stem growth. Some went through two or three oscillations in 8 years. Some stems took two to three years to reshoot again. Some oscillations were probably missed as monitoring was carried out once a year for the last 6 years. Very thin stems that had died were visible on the wire cage mesh. Lesser fluctuations in height where the plant did not dieback all the way to ground level were also common (not classed as an oscillation).

Some small stems recorded very little change in height in eight years and no oscillation (Table 8 – S1 5%). In the T category (31%), most stems maintained or increased height over eight years without declining much in height. Oscillations in the T category were 4%, much lower than D and S.

Figure 4 shows the percentage of D, S and T plants within recipient sites. The percentages are fairly constant amongst the 7 sites except for sites 3 and 8(a). Site 8 (a) was probably affected by herbicide spray drift. Site 3 was exceptional in the rapid growth and height of plants, suggesting that the greater openness of this site promoted stem growth. It is possible that variation in height growth response was due to the size of plants introduced. However, the initial size of rescued plants in terms of volume of soil supporting stem and root system (i.e. ~30 cm x 10 cm x 10 cm) did not vary greatly. Large stems were rare and only a few transplanted. It is interesting that for the other 5 sites, percentages of D, S and T plants are similar in each site (Figure 4). This could be interpreted as the effect of random variation in plant size when transplanted, or random variation in planting microsites within the recipient site. The thickness or volume of rhizomatous roots within the slab (not recorded) may have affected individual performance.

Table 8: Number of individuals of Slender Marsdenia in different stem height growth categories at seven recipient sites and all sites combined, eight years after translocation. Actual number of stems and the percentage per site and overall are shown. Categories S and T are considered surviving (survivorship 55%).

	Recipient Sites/ Height Growth Categories	**Cb**	**%**	**3**	**%**	**5**	**%**	**5a**	**%**	**7a**	**%**	**8a**	**%**	**8c**	**%**	**All**	**%**
	Total Slender Marsdenia	27		17		10		21		57		8		27		167	100%
D	**Ht = 0 at Dec/2022, may be dead or may reshoot**																
D1	Never reshot	1	4%	0	0%	0	0%	1	5%	3	5%	0	0%	0		5	3%
D2	Small shoot then died back to ground, probably dead	4	15%	2	12%	2	20%	0	0%	5	9%	1	13%	2	7%	16	10%
D3 (O)	Reshot, reached small to medium height (<1.2 m) then died back to ground, some fluctuated (i.e. dieback-reshoot-dieback)	2	7%	1	6%	2	20%	8	38%	27	47%	2	25%	6	22%	48	29%
D4	Reshot, grew tall (~2 m+) then died back to ground, probably dead	0	0%	0	0%	0	0%	0	0%	0	0%	1	13%	5	19%	6	4%
	All D	7	26%	3	18%	4	40%	9	43%	35	61%	4	50%	13	48%	75	45%
D	oscillations	2	7%	1	6%	1	10%	4	19%	16	28%	0	0%	7	26%	31	19%
S	**Small, growing very slowly, or declining**															0	
S1	Stayed small, mostly less than 10 cm high (some to 50 cm), little height change in 6 yrs	1	4%	0	0%	1	10%	3	14%	2	4%	0	0%	2	7%	9	5%
S2 (O)	Died back to ground and reshot once or twice, continuously small (mostly <50 cm)	5	19%	0	0%	2	20%	1	5%	3	5%	0	0%	2	7%	13	8%

S3	Declining or bell shaped (increase-decrease), some to ~130cm at peak, continuously alive but stem mostly small (<50 cm)	1	4%	0	0%	0	0%	1	5%	3	5%	0	0%	2	7%	5	3%
S4 (O)	Fluctuating – e.g. ‘small-medium/tall-small’; or ‘grew medium/tall then died back to small	4	15%	0	0%	0	0%	4	19%	2	4%	0	0%	1	4%	10	6%
	All S	11	41%	0	0%	3	30%	9	43%	10	18%	0	0%	7	26%	40	24%
S	oscillations	9	33%	0	0%	2	20%	6	29%	3	5%	0	0%	3	11%	23	14%
T	**Thriving, plant relatively tall, continuing to grow, or maintaining size, healthy**																
T1	Tall (1.5 m+), substantial increase in height/no. of leaves, or maintained height	1	4%	5	29%	1	10%	1	5%	5	9%	1	13%	3	11%	17	10%
T2	Moderately tall (0.75 – 1.5 m +), moderate increase in height (δ = 0.5 – 1 m or more), or height constant	1	4%	7	41%	2	20%	2	10%	7	12%	3	38%	4	15%	26	16%
T3 (O)	Died back to ground then reshot vigorously (>1 m)	6	22%	2	12%	0	0%	0	0%	0	0%	0	0%	0	0%	8	5%
T4	Small for several monitoring events then suddenly grew taller (>1 m)	1	4%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	1	1%
	All T	9	33%	14	82%	3	30%	3	14%	12	21%	4	50%	7	26%	52	31%
T	oscillations	5	19%	0	0%	0	0%	1	5%	1	2%	0	0%	0	0%	7	4%
																0	
	Oscillating individuals	**16**	59%	**1**	6%	**3**	30%	**11**	52%	**20**	35%	**0**	0%	**10**	37%	61	37%
	1 oscillation	**12**	44%	**1**	6%	**3**	30%	**7**	33%	**17**	30%	**0**	0%	**4**	15%	44	26%
	2 oscillations	**4**	15%	**0**	0%	**0**	0%	**4**	19%	**3**	5%	**0**	0%	**6**	22%	17	10%
	Survivorship	**74%**		**82%**		**60%**		**57%**		**39%**		**50%**		**52%**			

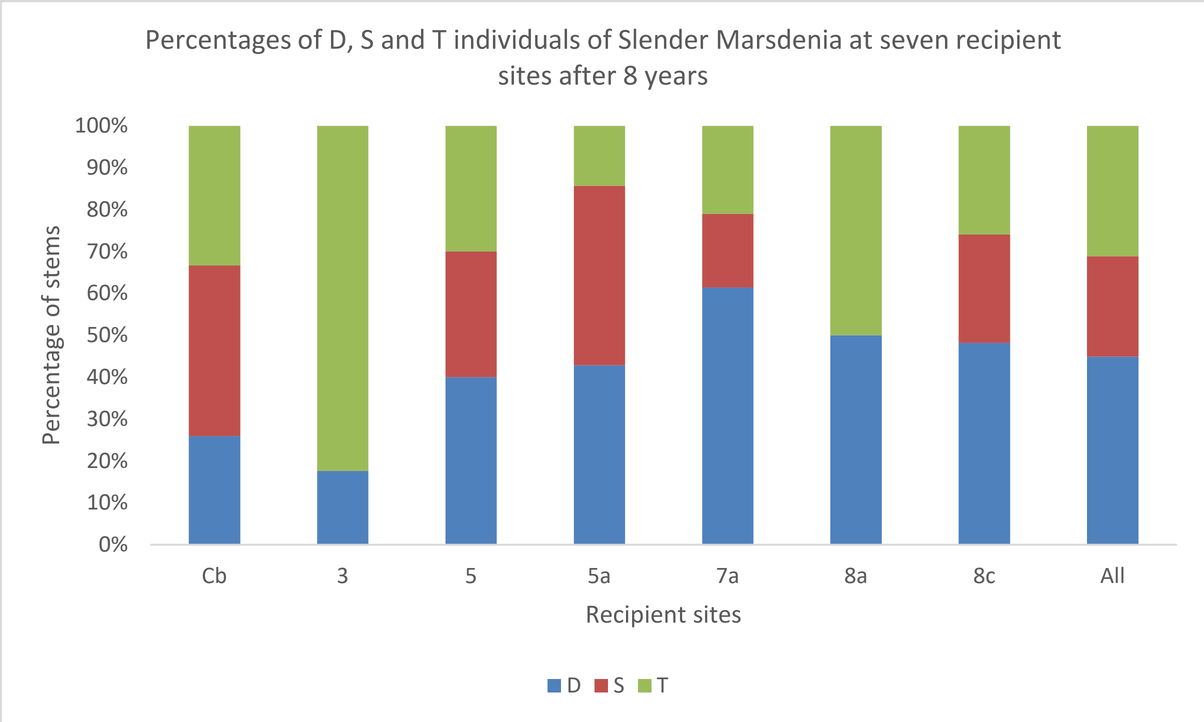

Figure 4: Percentage of D (ht = 0), S (small) and T (tall) plants at each of the recipient sites and all sites combined at the Dec/2022 monitoring, 8 years after translocation. The percentages are fairly constant amongst the sites except for sites 3 and 8(a).

Possible causes of oscillatory stem growth in Slender Marsdenia include seasonal variation in growth conditions (e.g. understorey shading, nutrient availability) resulting in cycles of new shoot growth and stem dieback, and exploratory gauging of the environment before committing to expenditure of stored resources in stem and leaf growth,

2.3.2.4 Comparison with stem height dynamics in in-situ plants

Monitoring of in-situ plants of Slender Marsdenia on the NH2U and WC2NH projects found that stem height fluctuation was present to much of the same extent in naturally occurring in situ populations, and the size class distribution of stems was also much the same in in-situ plants. Most plants were small stem shoots and died back at least once. Large in-situ plants (>2.5 m) with foliage in the forest mid-stratum were very rare.

2.3.2.5 Reproduction

Flowering

A total of four out of 163 translocated plants flowered in eight years, which included three plants that flowered this year. The number of flowers per inflorescence was very small.

A low incidence of flowering in translocated Slender Marsdenia was also recorded on the NH2U project (one individual) and Bonville project (three individuals) (Ecos Environmental 2016 and 2013).

No flowering was recorded in in-situ plants. Flowering is rarely observed in naturally occurring Slender Marsdenia. However, flowers and pods have a neutral green/cream colour that blends in with mid-stratum foliage so are easily overlooked.

Vegetative reproduction

Oscillating stem growth was common in Slender Marsdenia but there was little evidence of clonal or vegetation reproduction. Rare shoots were observed toward the edge of the wire cylinder or just outside (30-40 cm from the centre), which appeared to represent root suckers, but it was difficult to be certain without digging them up and risk killing plants. One or two stem shoots were produced further out (0.5m), which may have been connected to the plant inside the wire cylinder. Overall, there was little evidence of vegetative or clonal reproduction in Slender Marsdenia after transplanting to the recipient sites, which was unexpected as the species is thought to be clonal. Other factors may trigger development of stem clones.

2.3.3 Rusty Plum (*Niemeyera whitei*)

Survival rate of transplanted Rusty Plums at Recipient Site 1 remained at 86% after eight years. All seven plants increased in height and were in good condition. A seedling was recorded at the base of the largest tree, which was cut back to 1.5 m during transplanting and has regrown to about 4.5 m from an original height of about 10 m. Although only one seedling has been recruited, this tree has clearly reached reproductive maturity after being transplanted, which has taken 6-7 years.

Direct seeding of Rusty Plum for population enhancement had a moderate success rate. In November 2021, four years after sowing, single seedlings (from 3 seeds) were present in 5 cylinders and 2 seedlings in one cylinder, at total of 6/14 cylinders (43%), the tallest seedling was 30 cm. Results were affected by poor quality seed, being collected in a drought year and loss of a few cylinders to persons unknown.

2.3.4 Wooll's Tylophora (*Tylophora woollsii* – unconfirmed)

Woolls' Tylophora survival declined from 67% to 33% in 2020-2021, and 33% to 17% in 2021-2022. This may be due to herbicide spray drift from track maintenance carried out by the local water supply authority. Remaining plants were in good condition.

2.3.5 Large-flowered Milk Vine (*Marsdenia liisae*)

Some of the Marsdenia vines salvaged to Recipient Site 5b were *Marsdenia liisae*, not *Marsdenia longiloba.* The leaves of this species are larger, thicker and often darker green. *Marsdenia liisae* is a rare species ranging between the Hastings River (Pt Macquarie) and the Nightcap Range, although is not listed as threatened. The survival rate of *Marsdenia liisae* was similar to *Marsdenia longiloba*.

2.3.6 Spider Orchid (*Dendrobium melaleucaphilum*)

The two Spider Orchid plants rescued from the footprint declined in condition between 2020 and 2021, apparently due to grazing of pseudobulbs by an unknown insect or mollusc. There was little new pseudobulb growth. Persistent terminal flower axes indicated most pseudobulbs had flowering in spring (August - September) but as in previous years, there was no evidence of seed set, possibly due to absence of pollinators.

2.3.7 Floyds Grass (*Alexfloydia repens*)

<u>Area 9a</u>

There was a marked decrease in Floyds Grass cover-abundance in Recipient Site 9a in December 2022 compared to 2021. Last year's report stated: "About half of the fenced area comprising Area 9a contained at least some Floyds Grass in Nov/2021, seven years after translocation. This is the same cover recorded last year, which has been approximately stable for about 3-4 years, although subject to maintenance (removal of Broad-leaved Paspalum) for the last 12 months. Plants are found on the side of the recipient site closest to Warrell Creek, about 10 m from the creek edge. The other half has a high percentage of Broad-leaved Paspalum (BLP), although this has been reduced by herbicide treatment and hand weeding in 2021 and hopefully will allow Floyds Grass to spread into it. A high density of native Ottochloa grass is present with Floyds Grass and tends to overtop it. Floyds Grass is favoured where there are low woody plants which it can climb to get above Ottochloa (only 20-30 cm high)."

In December 2022, the total area of Floyds Grass was estimated at 10 m² or about 5% of the fenced area referred to above. Rather than a continuous cover of Floyds Grass, as recorded in previous years, occurrence in the 10 m² was fragmented. The section in the southeast corner of the fenced area where Floyds Grass had been dominant, was dominated by Ottochloa this year – see Plates 25 to 31. Overall, Floyds Grass appears to have declined by more than 50% compared to last year.

There was no obvious cause for the decline. The site experienced flooding in 2021-22 but Floyds Grass habitat being on creekbanks is often flooded. Ottochloa has been observed competing strongly with Floyds Grass at other locations. The population dynamics and interaction of these two species are poorly understood. It is possible that natural fluctuations in cover-abundance of both species occur naturally, and it will swing back to Floyds Grass next year. Growing conditions appear to have been particularly favourable for Ottochloa this year.

The site has been subject to a weed control program focusing on Broad-leaved Paspalum for two years. No adverse effects were observed last year after implementation of the program for a year, so it appears that the natural population dynamics of Floyds Grass and Ottochloa are driving the changes in species abundance. As the site was inspected only once a year, it is difficult to assess when and how quickly species abundance changed, if it corresponded with a certain season or weather event, or what other factors may have influenced the decrease in Floyds Grass.

<u>Area 9b</u>

A small amount of Floyds Grass was still present in Area 9b in 2022. A total of 12 small clumps of Floyds Grass, 5 cm x 10 cm up to 20 cm x 20 cm, were counted.

Last year's report stated: - "Floyds Grass is still present in this section in small clumps along the rows and has declined since 3 years ago. In 2021, the area was intensively treated with the aim of removing BLP, which was smothering remaining Floyds Grass. Selective herbicide was tried but found to be ineffective."

A buffer around the two areas has been planted with local native species, which are establishing well.

The cover-abundance of Floyds Grass remaining in Sites 9a and 9b in December 2022 is greater than the small amount of Floyds Grass impacted on the bank of Warrell Creek at the bridge construction site.

2.3.8 Koala Bells (*Artanema fimbriatum*)

Koala Bells transplanted from the footprint to Recipient Site 8a died out after two years. Flowering and seeding occurred in the first and second years. Seed was produced and dormant seed may be present in the soil seedbank. The Site 8a is located next to a watermain easement that appears to be maintained by annual herbicide spraying (not evident when the translocations were carried out) which may have affected the Koala Bells planted next to the track (as well as Slender Marsdenia Recipient Site 8a).

Propagated Koala Bells were introduced to Recipient Site 9b in autumn 2017 when the plants were flowering and seeding. Recruitment of more plants, apparently from seed although they could have been root suckers, was recorded a few months later in spring 2017. These plants persisted until spring 2019 then all died out by spring 2020. No more plants appeared in 2021 as the site became overgrown with BLP or were seen in 2022 after weeding had been carried out.

2.4 Performance Criteria

Table 9: Performance Criteria for Assessing Threatened Translocation Areas

Performance criteria	Yes/No
1. All recorded directly impacted individuals were translocated.	Yes
2. At least 60% of transplant and enhancement individuals are surviving after the first year, 50% after five years and 40% after eight years.	Mostly Yes
3. At the end of the monitoring program at least 50% of surviving individuals have a Condition Class of 3.	Yes
4. Habitat at recipient sites in good condition conducive to medium term survival (i.e. 10 years)	Yes

2.5 Work Schedule

No further works are proposed for the Translocation Recipient Sites on the WC2NH project as the requirements of the Threatened Flora Management Plan have been completed.

3 In-Situ Threatened Flora Populations

3.1 Methods

In-situ Threatened Flora Populations comprise the following threatened species:

- Maundia (*Maundia triglochinoides*)
- Rusty Plum (*Niemeyera whitei*)
- Slender Marsdenia (*Marsdenia longiloba*)
- Spider Orchid (*Dendrobium melaleucaphilum*)
- Woolls' Tylophora (*Tylophora woollsii*).

Individuals of these threatened species were located and tagged before clearing and construction of the WC2NH project began. All individuals occurred within the project boundary but outside the clearing limit (Figures 5-9).

GeoLINK conducted pre-construction and construction monitoring of in-situ threatened flora between January 2015 and October 2017. The following identification and condition data were recorded for each in-situ plant:

- Genus and species
- Plant identification number
- Overall plant condition scored on scale between 0 and 5 (see Tables 2-4)
- Presence of flowers and/or fruit
- Any new growth
- Any recruitment
- Any weed infestations or other impacts.

See *Warrell Creek to Nambucca Heads Monitoring of In-situ Threatened Flora (Annual Report – Spring 2017)* (GeoLINK 2017) for more information.

Ecos Environmental conducted the first yearly operational phase monitoring of the in-situ threatened species in November 2018. All tagged plants were located and the same condition data as recorded by GeoLINK were collected. Additionally, Ecos Environmental recorded the height of each individual to assess plant growth and performance throughout the monitoring program. In November 2021, Ecos Environmental conducted the fourth yearly operational phase monitoring, which is described in this report.

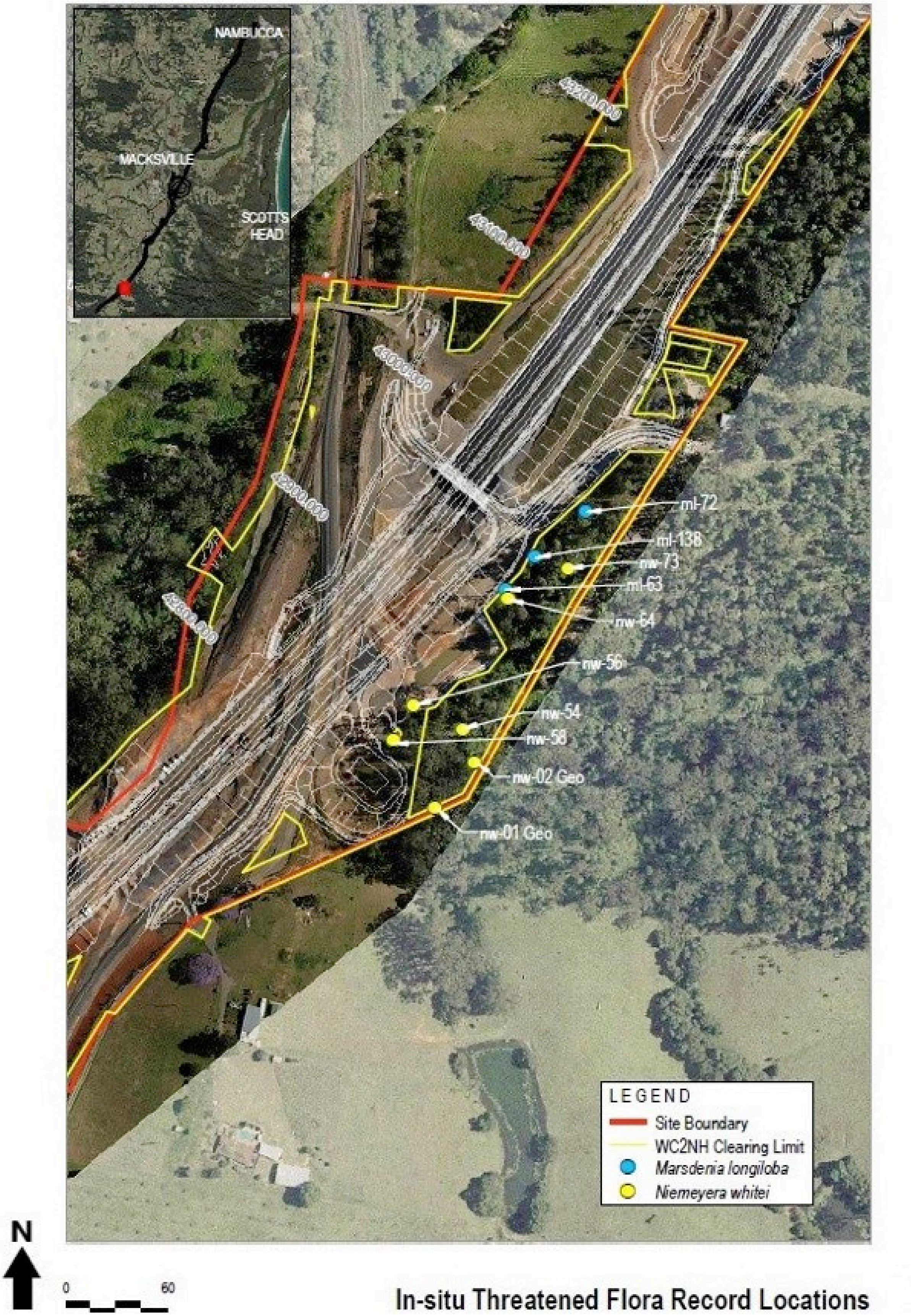

Figure 5: In-situ Slender Marsdenia and Rusty Plum at Cockburns Lane, WC2NH. Map sourced from GeoLINK (2017).

Figure 6: Maundia population at Nambucca Floodplain, WC2NH. Map sourced from GeoLINK (2017).

Figure 7: In-situ Slender Marsdenia, WC2NH. Map sourced from GeoLINK (2017).

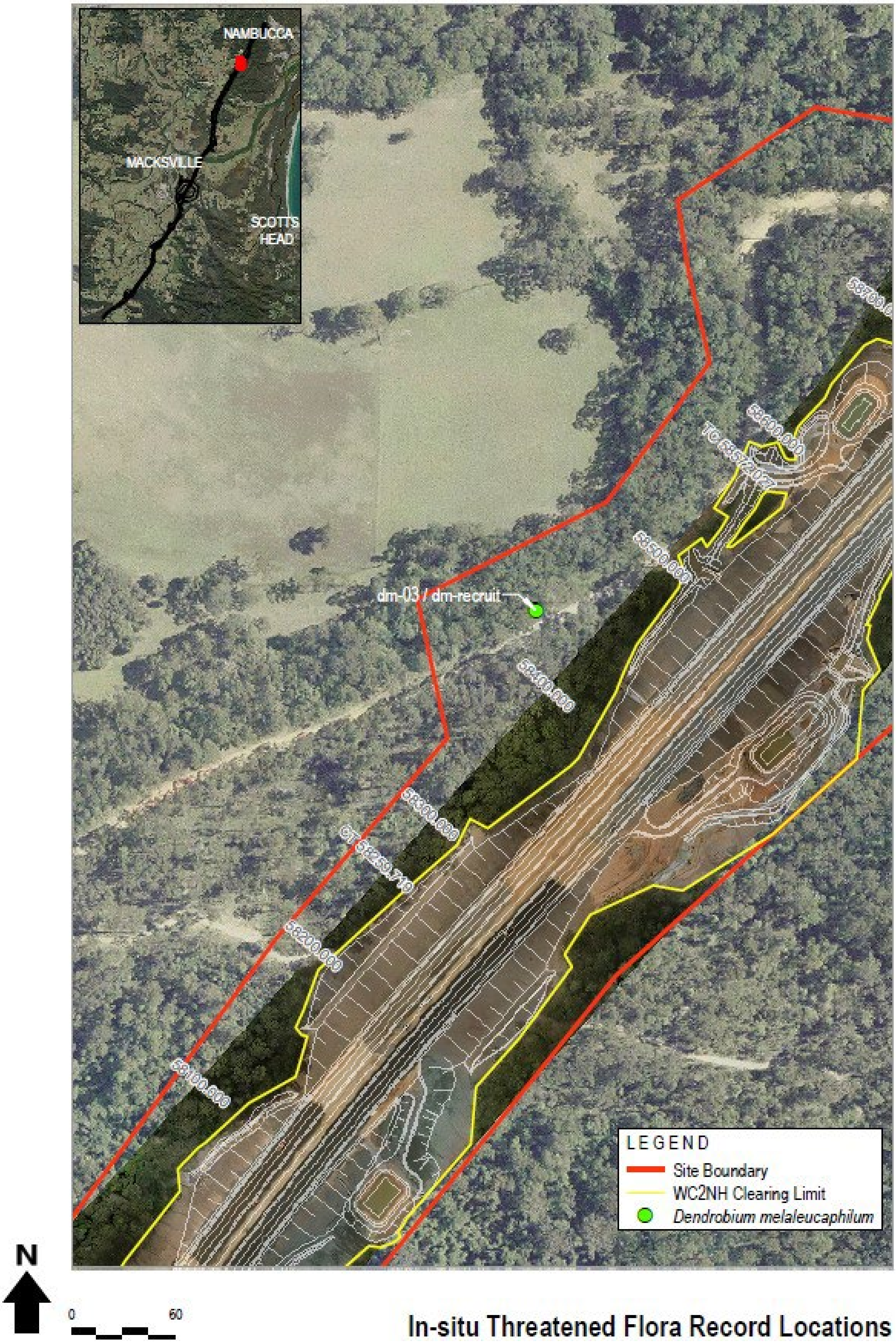

Figure 8: In-situ Spider Orchid, WC2NH. Map sourced from GeoLINK (2017).

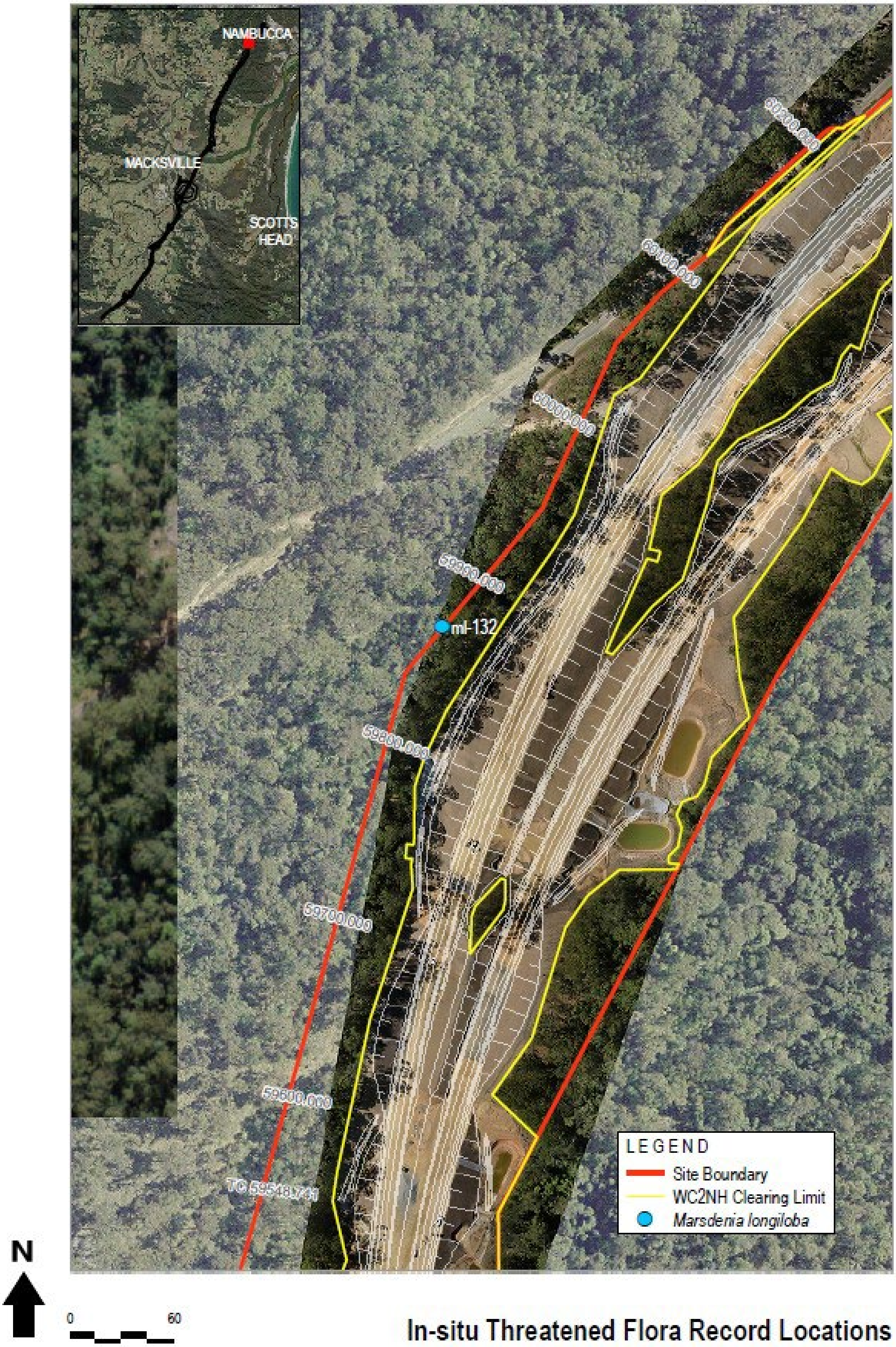

Figure 9: In-situ Slender Marsdenia, WC2NH. Map sourced from GeoLINK (2017).

3.2 Results

See Appendix 2 for photos of the in-situ threatened plant species in December 2022.

3.2.1 Maundia (*Maundia triglochinoides*)

In November 2018, Maundia had a crown-cover of 40% in the monitoring plot and extended well beyond the plot forming a large population. By November 2019, Maundia had almost disappeared from the plot (Table 11) and surrounding area due to drought conditions. Only a few yellowing leaves were seen. There was no standing water in the swamp and it was dry enough to walk across. The main wetland plant was an *Eleocharis* species, which was unaffected by the dry conditions, as were Ludwigia and several other species. It appears that Maundia requires at least some standing water and a flooded substrate to maintain green growth, otherwise it dies off.

Following the end of the drought in 2020 and flooding rains, Maundia began to recover and by December 2022 had a crown cover of 50-60%, similar to or more than recorded in 2018. Flowering Maundia plants were common.

3.2.2 Spider Orchid (*Dendrobium melaleucaphilum*)

The large Spider Orchid plant (DM03) appeared to have deteriorated. There were more dead pseudobulbs and not many with leaves. Nearly all pseudobulbs had flowered last spring, including dead ones, although no seed pods were formed. This year the plant had 70 pseudobulbs, 8 with leaves and 30 dead pseudobulbs. Sixty pseudobulbs had flowered, but no pods.

3.2.3 Rusty Plum (*Niemeyera whitei*)

All seven in-situ Rusty Plums at Cockburns Lane were alive and in reasonable condition in November 2021 (Table 13). A few fruits were observed this year.

Habitat condition at the Cockburns Lane site in November 2021 was generally good. Lantana was scattered throughout the site although did not appear to be having a negative effect on Rusty Plum or Slender Marsdenia, which also occurs at site.

3.2.4 Slender Marsdenia (*Marsdenia longiloba*)

The monitoring program includes five in-situ Slender Marsdenia occurrences across three locations (Table 14). Monitoring Slender Marsdenia through time can be difficult as plants often die back and reshoot and new stems may emerge from underground rhizomes away from old stems, making it appear that plants have changed location. This is part of Slender Marsdenia’s natural growth pattern and life cycle rather than a response to human-related disturbances.

In December 2022, Slender Marsdenia was present at all five in-situ locations. In most locations there was more than one stem and so height and plant condition was recorded for the largest stem. The height (of the largest stem) of individuals ranged from 10 cm to 2m and condition score ranged from 2 to 4 (Table 14).

The largest in situ Slender Marsdenia occurrence being monitored - ML93 - consists of a clonal patch of small stem-individuals growing across the fence line along Old Coast Road in remnant forest in the road reserve and adjoining property. In December 2022, this patch consisted of about 12 stems within an area approx. 15 m x 10 m, extending from the edge of Old Coast Road to the base of a large Tallowwood (*Eucalyptus microcorys*) and several more in grass on the roadside. Most stems were small (<20 cm high) and none exceeded one metre high. No flowering or fruiting was observed. Recruitment in this patch is mostly likely vegetative or asexual by production of stems from underground tuberous roots.

At ML132 shoots remained small (<10 cm high). Stems at ml-72, ml-138 and ml-63 occur at Cockburns Lane (same site as in-situ Rusty Plum) were small and one 1 m high.

Table 11: In-situ threatened flora monitoring results for Maundia (*Maundia triglochinoides*) recorded by Ecos Environmental 2019-2022

Maundia (*Maundia triglochinoides*)																
Population	Cover-Abundance and (Condition Class Score)			Flower/ Fruit Present			New Growth			Recruitment			Damage/ Disturbance			Site Conditions (Spr 2022
	Spr 2019	Spr 2020	Spr 2022	Spr 2019	Spr 2020	Spr 2022	Spr 2019	Spr 2020	Spr 2022	Spr 2019	Spr 2020	Spr 2022	Spr 2019	Spr 2020	Spr 2022	
Nambucca Floodplain	<1%	20%	60%	N	Y	Y	Y	Y	Y	Y	N	Y	N	N	N	Canopy height 10-14m m with *Melaleuca quinquenervia* dominant species; ground stratum 100% crown-cover; water to 20 cm deep; exotic grass spp. along fauna fenceline with road.

Table 11: In-situ threatened flora monitoring results for Maundia (*Maundia triglochinoides*) recorded by Ecos Environmental 2019-2022.

Maundia (*Maundia triglochinoides*)																
Population	Cover-Abundance and (Condition Class Score)			Flower/ Fruit Present			New Growth			Recruitment			Damage/ Disturbance			Site Conditions (Spr 2022)
	Spr 2019	Spr 2020	Spr 2022	Spr 2019	Spr 2020	Spr 2022	Spr 2019	Spr 2020	Spr 2022	Spr 2019	Spr 2020	Spr 2022	Spr 2019	Spr 2020	Spr 2022	
Nambucca Floodplain	<1%	20%	60%	N	Y	Y	Y	Y	Y	Y	N	Y	N	N	N	Canopy height 10-14m m with *Melaleuca quinquenervia* dominant species; ground stratum 100% crown-cover; water to 20 cm deep; exotic grass spp. along fauna fenceline with road.

Table 12: In-situ threatened flora monitoring results for Spider Orchid (*Dendrobium melaleucaphilum*) recorded by Ecos Environmental 2018 – 2022.

Plant ID #	Length of longest pseudobulb (cm)			Leaf Condition			Number of pseudobulbs with leaves			New Growth			Recruitment			Damage/ Disturbance			Site Conditions	GeoLINK notes (PC 2015-Spr 2017)	Ecos Environmental notes (Spr 2022)
	Spr 2019	Spr 2020	Spr 2022	Spr 2019	Spr 2020	Spr 2022	Spr 2019	Spr 2020	Spr 2022	Spr 2019	Spr 2020	Spr 2022	Spr 2019	Spr 2020	Spr 2022	Spr 2019	Spr 2020	Spr 2022			
3	35	35	25	5	5	2	50+	50	12	N	Y	N	N	N	N	N	N	N	Canopy height 25 m and crown-cover approx 90% comprised of Eucalyptus spp.	Very healthy with signs of increased flowering activity.	Fairly healthy, effect of dry conditions evident in many dead and ratty pseudobulbs
DM Recruit	12	12	6	3	3	2	4	4	2	N	N	N	N	N	N	N	N	N		This new recruit was first observed during Spring 2016.	

Table 13: In-situ threatened flora monitoring results for Rusty Plum (*Niemeyera whitei*) recorded by Ecos Environmental 2018 – 2022.

Plant ID #	Height (cm)			Leaf Condition			Flower/ Fruit Present			New Growth			Recruitment			Damage/ Disturbance			Site Conditions (Spr 2022)
	Spr 2019	Spr 2020	Spr 2022	Spr 2019	Spr 2020	Spr 2022	Spr 2019	Spr 2020	Spr 2022	Spr 2019	Spr 2020	Spr 2022	Spr 2019	Spr 2020	Spr 2022	Spr 2019	Spr 2020	Spr 20222	
NW58	800	820	920	4	4	4	N	N	N	Y	Y	Y	N	N	N	N	N	N	Canopy height 20 m with crown-cover 70%; some medium to large patches of Lantana scattered throught site.
NW56	120	130	140	4	4	4	N	N	N	Y	Y	Y	N	N	N	N	N	N	
NW73	700	750	760	5	4	4	Y	N	N	N	Y	Y	N	N	N	N	N	N	
NW54	600	640	650	4	4	4	N	N	N	N	Y	Y	N	N	N	N	N	N	
NW64	800	850	870	5	4	4	Y	N	N	N	N	N	N	N	N	N	N	N	
NW01-Geo	450	450	480	4	4	4	N	N	N	N	Y	Y	N	N	N	N	N	N	
NW02-Geo	500	530	570	4	4	4	N	N	N	N	Y	Y	N	N	N	N	N	N	

Table 14: In-situ threatened flora monitoring results for Slender Marsdenia (*Marsdenia longiloba*) recorded by Ecos Environmental 2018 - 2022

Plant ID	Height (cm)			Leaf Condition			Flower/ Fruit Present			New Growth			Recruitment			Damage/ Disturbance			Site Conditions	GeoLINK notes (PC 2015-Spr 2017)	Ecos Environmental notes (Spr 2018-to Spr 2022)
	Spr 2019	Spr 2020	Spr 2022	Spr 2019	Spr 2020	Spr 2022	Spr 2019	Spr 2020	Spr 2022	Spr 2019	Spr 2020	Spr 2022	Spr 2019	Spr 2020	Spr 2022	Spr 2019	Spr 2020	Spr 2022			
ML93	130	18	6	2	3	3	Spr 2098	Spr 2020	N	Y	Y	N	N	Y	N	N	N	N	Canopy height 20 m; crown-cover 100% with Eucalyptus microcorys dominant species.	15 live plants now within 1 m radius of subject plant. All range from 2 – 4 in condition class. Some plants recorded during spring 2016 have died back however new recruits have also been recorded and are now at a count of 23 flagged individual plants.	Clonal patch, no. variable 15-30 individuals in an area 15m x 10 m, from the base of E. microcorys to the edge of O)ld Coast Rd. In 2018, most plants small (<20cm high), a few >1 m high. In 2021, all small.
ML132	10	5	25	2	3	3	N	N	N	Y	Y	Y	N	N	N	N	N	N	Canopy height 25 m; crown-cover 80%	During Spring 2016 partially natural die back was recorded. The plant recorded during spring 2017 is fresh, green with new growth indicating possibly a new plant to the one previously recorded.	Most shoots tagged 2018 had died off. Two small shoots (<10 cm tall) in 2021 about 1 m apart
ML72	10	10	0	2	3	3	N	N	N	N	N	N	N	N	N	N	N	N	Canopy height 20 m; crown-cover 70%	Natural die back of the stem, possibly live stem bulb. No obvious signs of construction related impacts.	Died back and reshot
Ml138	90	10	141	3	3	3	N	N	N	Y	N	Y	N	N	N	N	N	N		Tall plant with mature leaves some yellowing.	Died back and reshot

ML63	10	300	150	2	4	4	N	N	N	N	Y	Y	N	N	N	N	N	N			Healthy

3.3 Conclusion

The survival rate of in-situ threatened flora species after approximately eight years (Dec 2022) was 100% for Spider Orchid, Rusty Plum and 70% for Slender Marsdenia. (Table15). Maundia does not occur as discrete individuals but as a sward of stems, so its abundance was measure just as crown-cover. The plot crown-cover of Maundia had increased from <1% at the peak of the drought to 50-60% in Dec 2022, the level of cover-abundance recorded before the drought. The survival rate of Slender Marsdenia remained stable although some stems had died back and reshot.

No signs of adverse effects on threatened flora related to highway operation were observed in Dec 2022. The monitoring results meet the performance criteria – *survival rate at the end of Years 4-8 is >70%* and *of surviving plants at end of each year >75% are in good condition (class 3 or >)* – for Spider Orchid, Rusty Plum and Slender Marsdenia and therefore no corrective actions are required for these species. Note that >75% of in-situ Slender Marsdenia plants do not have a class score of 3 or > as they were not taller than 75 cm, but this is not of concern for this species because of the tendency for stems to dieback and regrow again.

Table 15: Performance measures for In-situ Threatened Flora Populations monitoring.

Species	Survival rate at finish of clearing (October 2015/ Spring 2015) is 100%, no accidental damage due to clearing	Survival rate at end of Years 1-3 is >80%	Survival rate at end of Year 4 (2018)	Survival rate at the end of Years 4-8 is >70%	Of surviving plants at end of each year >75% are in good condition (class 3 or >)			
					Year 3 - 2017	Year 5 - 2019	Year 6 - 2020	Year 8 - 2022
Spider Orchid (*Dendrobium melaleucaphilum*)	Yes - 100% survival No accidental damage due to clearing	Yes - 100% survival	Yes - 100%	Not applicable yet	Yes - 100% in good condition, with new recruit. recorded also in good condition (score 3)	Yes - 100% (including new recruit) in good condition (Score 4)	Yes - 100% with one plant reproductive	Yes - 100% with one plant reproductive
Maundia (*Maundia triglochinoides*)	Yes - 100% survival No accidental damage due to clearing	Yes - 83% survival	No - <1% survival (trace)%	Not applicable yet	Yes - 100% in good condition (score 5)	Yes - 100% of visible plants in good condition (score 3)	No – poor condition (score 1)	Yes – good recovery after the drought, flowering (score 3)
Rusty Plum (*Niemeyera whitei*)	Yes - 100% survival No accidental damage due to clearing	Yes - 100% survival	Yes - 100%	Not applicable yet	Yes - 80% in good condition (score 2 - 5)	Yes - 100% in good condition (score 3 - 5)	Yes - 100% with some plants reproductive	Yes - 100% with some shoot growth
Slender Marsdenia (*Marsdenia longiloba*)	No - 62% of plants were recorded as living But no construction related impacts were recorded	No - 60%	Yes - 100%	Not applicable yet	Yes - 100% (5 of 5 records) recorded scores 3 - 4	No - 60% (3 of 5 records) recorded scores 1 - 4	No - 40% in good condition	Yes - 70% in good condition

4 Slender Marsdenia and Woolls' Tylophora Habitat Condition

4.1 Methodology

This component of the Threatened Flora Management Plan aims to monitor Slender Marsdenia and Woolls' Tylophora habitat in the indirect impact zone – i.e. within 10 m of the edge of clearing – for potential edge effects and declines in habitat condition. The study design involves ten permanent plots along the edge of clearing in known Slender Marsdenia and Woolls' Tylophora habitat (Figures 10-12). Each plot is 10 m * 20 m with the long axis parallel to the edge of clearing. Within each plot, the following vegetation and landscape attributes are measured:

- Native vegetation structure (according to Native Vegetation Interim Type Standard)
- Level of weed incursion (measured by summing the abundance of all exotic species)
- Microclimate class (Table 16).

The plots were established by GeoLINK on 26 November 2015 around the time that clearing operations in the northern zone of the project were being completed and monitored the plots again in autumn and spring 2016 and spring 2017 (GeoLINK 2017).

Ecos Environmental carried out the first yearly operation phase monitoring of the ten plots in November 2018. Native vegetation structure was measured according to the following guidelines: "Structure consists of the height, crown-cover and dominant species in each vegetation layer and will be recorded according to the current OEH Native Vegetation Interim Type Standard (www.environment.nsw.gov.au/research/VISplot.htm)." - p27.

Ecos Envrionmetal carried out the fifth yearly operation phase monitoring in December 2022, which is described in this report.

Table 16: Microclimate exposure classes for Slender Marsdenia and Woolls' Tylophora habitat.

Microclimate Class (less exposed to more exposed)	Microclimate Type
1	Sheltered aspect (e.g. south) and vegetation understorey slightly more open and exposed than before clearing.
2	Sheltered aspect (e.g. south) and vegetation understorey moderately more open and exposed than before clearing.
3	Sheltered aspect (e.g. south) and vegetation understorey much more open and exposed than before clearing.
4	Exposed aspect (e.g. east, north and west) and vegetation understorey slightly more open and exposed than before clearing.
5	Exposed aspect (e.g. east, north and west) and vegetation understorey moderately more open and exposed than before clearing.
6	Exposed aspect (e.g. east, north and west) and vegetation understorey much more open and exposed than before clearing.

Figure 10: Slender Marsdenia and Woolls' Tylophora Habitat monitoring quadrats 5, 6, 7 and 8, WC2NH. Map sourced from GeoLINK (2017).

Figure 11: Slender Marsdenia and Woolls' Tylophora Habitat monitoring quadrats 9 and 10, WC2NH. Map sourced from GeoLINK (2017).

Figure 12: Slender Marsdenia and Woolls' Tylophora Habitat monitoring quadrats 1, 2, 3 and 4, WC2NH. Map sourced from GeoLINK (2017).

4.2 Results

Since spring 2015 the level of weed incursion has increased in some plots and decreased in others (Table 17). All changes, however, are minor with weed crown-cover remaining far below the performance measure threshold of 25%. The data also indicates that the microclimate of some plots in spring 2021 differs from previous years. Specifically, that plots 6, 7, 8, 9 and 10 became more exposed. The data, however, should be interpreted cautiously as it was collected by two different observers – GeoLINK from 2015-2017 and Ecos Environmental in 2018-2022 – and therefore likely reflects observer variability.

Table 17: Weed level and microclimate class of Slender Marsdenia and Woolls' Tylophora habitat plots.

Plot	Weed Level (crown-cover)	Microclimate Class
1	Lantana	
Spring 15 (GeoLINK)	<5	5
Autumn 16 (GeoLINK)	5	5
Spring 16 (GeoLINK)	5	5
Spring 17 (GeoLINK)	5	5
Spring 18 (Ecos)	<5	5
Spring 19 (Ecos)	5	5
Spring 20 (Ecos)	5	5
Spring 21 (Ecos)	4	4
Spring 22 (Ecos)	4	4
2	Lantana, Whisky Grass	
Spring 15 (GeoLINK)	<5	5
Autumn 16 (GeoLINK)	5	5
Spring 16 (GeoLINK)	10	5
Spring 17 (GeoLINK)	10	5
Spring 18 (Ecos)	<5	5
Spring 19 (Ecos)	<5	5
Spring 20 (Ecos)	5	5
Spring 21 (Ecos)	2	4
Spring 22 (Ecos)	2	4
3	Lantana	
Spring 15 (GeoLINK)	<5	1
Autumn 16 (GeoLINK)	<5	1
Spring 16 (GeoLINK)	<5	1
Spring 17 (GeoLINK)	<5	1
Spring 18 (Ecos)	<5	2
Spring 19 (Ecos)	<5	2
Spring 20 (Ecos)	<5	3
Spring 21 (Ecos)	<5	3
Spring 22(Ecos)	<5	3
4	Lantana	
Spring 15 (GeoLINK)	0	2
Autumn 16 (GeoLINK)	0	2

Plot	Weed Level (crown-cover)	Microclimate Class
Spring 16 (GeoLINK)	0	2
Spring 17 (GeoLINK)	0	2
Spring 18 (Ecos)	<5	2
Spring 19 (Ecos)	<5	2
Spring 20 (Ecos)	<5	2
Spring 21 (Ecos)	<3	2
Spring 21 (Ecos)	<3	2
Spring 22 (Ecos)	<3	2
5	Lantana, Setaria, Broad-leaved Paspalum	
Spring 15 (GeoLINK)	<5	5
Autumn 16 (GeoLINK)	<5	5
Spring 16 (GeoLINK)	<5	5
Spring 17 (GeoLINK)	<5	5
Spring 18 (Ecos)	<5	5
Spring 19 (Ecos)	<5	5
Spring 20 (Ecos)	<5	5
Spring 21 (Ecos)	<5	5
Spring 22 (Ecos)	<5	5
6	Lantana	6
Spring 15 (GeoLINK)	5	4
Autumn 16 (GeoLINK)	5	4
Spring 16 (GeoLINK)	5	4
Spring 17 (GeoLINK)	5	4
Spring 18 (Ecos)	<5	5
Spring 19 (Ecos)	10	5
Spring 20 (Ecos)	10	5
Spring 21 (Ecos)	5	4
Spring 22 (Ecos)	5	5
7	Broad-leaved Paspalum	
Spring 15 (GeoLINK)	0	1
Autumn 16 (GeoLINK)	0	1
Spring 16 (GeoLINK)	0	1
Spring 17 (GeoLINK)	0	1
Spring 18 (Ecos)	<5	2
Spring 19 (Ecos)	0	2
Spring 20 (Ecos)	0	2
Spring 21 (Ecos)	0	2
Spring 22 (Ecos)	0	2
8	Lantana	
Spring 15 (GeoLINK)	5	1
Autumn 16 (GeoLINK)	5	1
Spring 16 (GeoLINK)	7	1
Spring 17 (GeoLINK)	5	1
Spring 18 (Ecos)	<5	2
Spring 19 (Ecos)	<5	2

Plot	Weed Level (crown-cover)	Microclimate Class
Spring 20 (Ecos)	<5	2
Spring 21 (Ecos)	<5	2
Spring 22 (Ecos)	<5	2
9	Lantana, Broad-leaved Paspalum, Coastal Morning Glory	
Spring 15 (GeoLINK)	5	1
Autumn 16 (GeoLINK)	5	1
Spring 16 (GeoLINK)	<5	1
Spring 17 (GeoLINK)	<5	1
Spring 18 (Ecos)	<5	2
Spring 19 (Ecos)	<5	2
Spring 20 (Ecos)	<5	2
Spring 21 (Ecos)	<5	2
Spring 22 (Ecos)	<5	2
10	Lantana, Billygoat Weed, Setaria	
Spring 15 (GeoLINK)	<5	4
Autumn 16 (GeoLINK)	<5	4
Spring 16 (GeoLINK)	<5	4
Spring 17 (GeoLINK)	<5	4
Spring 18 (Ecos)	<5	5
Spring 19 (Ecos)	<5	5
Spring 20 (Ecos)	<5	5
Spring 21 (Ecos)	<5	2
Spring 22 (Ecos)	<5	4

Table 18: Vegetation structure of ten Slender Marsdenia and Woolls' Tylophora habitat monitoring plots, WC2NH. Data recorded December 2022 by Ecos Environmental.

Stratum	Dominant species	Cover (% crown-cover)	For the entire		
Plot 1					
Upper	*Eucalyptus grandis*	10	Upper stratum Height to crown (m) min-mode-max		
Upper	*Syncarpia glomulifera*	20			
Upper			20	20	30
Mid	*Lophostemon confertus*	20	Mid stratum Height to crown (m) min-mode-max		
Mid	*Cissus hypoglauca*	65			
Mid	*Acacia binervata*	15	4	5	10
Lower	*Blechnum cartilagineum*	30	Lower stratum Height to crown (m) min-mode-max		
Lower	*Dodonaea triquetra*	15			
Lower	*Cordyline stricta*	10	0.5	2	4
Plot 2					
Upper	*Syncarpia glomulifera*	50	Upper stratum Height to crown (m) min-mode-max		
Upper	*Eucalyptus microcorys*	20			
Upper	*Allocasurina torolosa*	15	15	24	28
Mid	*Cissus hypoglauca*	40			

Stratum	Dominant species	Cover (% crown-cover)	For the entire		
Mid	*Calicoma seratifolia*	15	Mid stratum Height to crown (m) min-mode-max		
Mid	*Trochocarpa laurina*	15	2	8	15
Lower	*Blechnum cartilagineum*	20	Lower stratum Height to crown (m) min-mode-max		
Lower	*Morinda jasminoides*	25			
Lower	*Cryptocarya rigida*	30	0.5	1	2
Plot 3					
Upper	*Syncarpia glomulifera*	15	Upper stratum Height to crown (m) min mode max		
Upper	*Eucalyptus grandis*	30			
Upper	*Eucalyptus anchorphylla*	10	28	28	30
Mid	*Cryptocarya rigida*	50	Mid stratum Height to crown (m) min mode max		
Mid	*Callicoma seratofolia*	30			
Mid	*Cissus hypoglauca*	40	4	5	12
Lower	*Blechnum cartilagineum*	30	Lower stratum Height to crown (m) min mode max		
Lower	*Livistonia australis*	30			
Lower	*Ripognum forcetianum*	15	0.5	1	3
Plot 4					
Upper	*Eucalyptus grandis*	30	Upper stratum Height to crown (m) min mode max		
Upper	*Eucalyptus glomulifera*	25			
Upper	*Eucalyptus acmenoides*	10	20	30	30
Mid	*Livistonia australis*	5	Mid stratum Height to crown (m) min mode max		
Mid	*Alphitonia excelsa*	20			
Mid	*Synoum glandulosum*	10	4	5	15
Lower	*Cissus hypoglauca*	50	Lower stratum Height to crown (m) min mode max		
Lower	*Gahnia sieberana*	20			
Lower	*Lepidosperma laterale*	5	0.5	1	2
Plot 5					
Upper	*Syncarpia glomulifera*	40	Upper stratum Height to crown (m) min mode max		
Upper	*Glochidion ferdinandii*	10			
Upper	*Gmelina leichhardtii*	10	15	18	20
Mid	*Livistonia australis*	15	Mid stratum Height to crown (m) min mode max		
Mid	*Guioa semiglauca*	30			
Mid	*Cissus hypoglauca*	20	7	10	12
Lower	*Cordyline stricta*	20	Lower stratum Height to crown (m) min mode max		
Lower	*Gahnia aspera*	15			
Lower	*Lomandra longifolia*	10	0.8	1	1.5
Plot 6					
Upper	*Eucalyptus pilularis*	40	Upper stratum Height to crown (m) min mode max		
Upper	*Lophostemon confertus*	20			
Upper	*Eucalyptus microcorys*	20	15	22	27
Mid	*Trochocarpa laurina*	15	Mid stratum Height to crown (m) min mode max		
Mid	*Acacia melanoxylum*	15			

Stratum	Dominant species	Cover (% crown-cover)	For the entire		
Mid	*Tabernaemontana pandacaqui*	20	5	8	12
Lower	*Cordyline stricta*	20	Lower stratum Height to crown (m) min mode max		
Lower	*Livistonia australis*	20			
Lower	*Blechnum cartilagineum*	10	0.5	1	2
Plot 7					
Upper	*Eucalyptus microcorys*	80	Upper stratum Height to crown (m) min mode max		
Upper	*Eucalyptus grandis*	10			
Upper			14	20	22
Mid	*Leptospermum polygalifium*	35	Mid stratum Height to crown (m) min mode max		
Mid	*Archirhodomyrtus beckleri*	10			
Mid	*Glochidion ferdinandi*	10	1.5	3	5
Lower	*Calochlaena dubia*	80	Lower stratum Height to crown (m) min mode max		
Lower	*Lomandra longifolia*	5			
Lower	*Blechnum cartilagineum*	5	0.5	0.7	1
Plot 8					
Upper	*Eucalyptus grandis*	70	Upper stratum Height to crown (m) min mode max		
Upper					
Upper			30	24	18
Mid	*Cissus hypoglauca*	20	Mid stratum Height to crown (m) min mode max		
Mid	*Rubus moluccanus*	20			
Mid	*Guioa semiglauca*	20	12	8	7
Lower	*Blechnum cartilagineum*	25	Lower stratum Height to crown (m) min mode max		
Lower	*Oplismenus imbecilis*	30			
Lower	*Morinda jasminoides*	15	2	1	0.3
Plot 9					
Upper	*Eucalyptus grandis*	15	Upper stratum Height to crown (m) min mode max		
Upper	*Corymbia intermedia*	30			
Upper	*Eucalyptus microcorys*	10	14	25	32
Mid	*Cryptocarya rigida*	30	Mid stratum Height to crown (m) min mode max		
Mid	*Livistonia australis*	15			
Mid	*Synoum glandulosum*	10	1.5	2.5	7
Lower	*Gahnia siberana*	5	Lower stratum Height to crown (m) min mode max		
Lower	*Lastreopsis* sp.	25			
Lower	*Cordyline stricta*	2	0.1	0.5	1
Plot 10					
Upper	*Eucalyptus grandis*	70	Upper stratum Height to crown (m) min mode max		
Upper					
Upper			20	25	28
Mid	*Melaleuca stypeloides*	10	Mid stratum Height to crown (m) min mode max		
Mid	*Lophostemon confertus*	10			
Mid	*Cissus antarctica*	20	2	8	10

Stratum	Dominant species	Cover (% crown-cover)	For the entire		
Lower	*Morinda jasminoides*	40	Lower stratum Height to crown (m) min mode max		
Lower	*Opplismenus imbecilis*	40			
Lower	*Cissus antarctica*	20	0.3	1.2	2

4.3 Conclusion

The monitoring plot data indicate there have been no declines in Woolls' Tylophora and Slender Marsdenia habitat condition along the edge of clearing. Different microclimate exposure scores assigned for some plots by GeoLINK (2017) most likely reflect observer variability rather than physical changes. Plot crown-cover of exotic species in Dec/2022 ranged from 0 to 10% or well below the performance threshold of 25%. Vegetation structure appeared to have remained the same. Therefore, no corrective actions are required (Table 19).

Table 19: Performance measures for Slender Marsdenia and Woolls' Tylophora Habitat Condition monitoring.

Performance measure	Yes/No – comments
Plot crown-cover of exotic species is no more than 25% at the end of Years-2 to 8.	Yes – plot crown-cover of exotic species at the end of year 6 is 0-10%
Baseline vegetation structure (height and crown-cover) remains the same or increases in height and crown-cover at the end of each year compared to the previous year.	Yes – qualitative assessment of vegetation structure data revealed no major decreases in height and crown-cover at the end of year 6 compared to year 5
There is no increase in the microclimate exposure class (e.g. 1 to 2, or 4 to 5) compared to the previous year.	No – the plots 6 and 10 maintained microclimate exposure score of 5 and plots 6-9 increased from 2 to 3, but this most likely reflects observer variability rather than physical changes.

5 Recommendations

No further management measures are recommended for the translocation recipient sites and in situ threatened flora on the WC2NH project based on this final monitoring report.

Given the marked decline of Floyds Grass at Recipient Site 9a and 9b at Warrell Creek, little gain is likely to result by carrying out further maintenance at the site.

After eight years of maintenance and monitoring, both translocated and in situ threatened species have been given a substantial boost to their chances of surviving over the long-term and establishing viable populations.

The only recommendation is for TfNSW to consider installing signage at each of the translocation recipient sites, clearly identifying them as **"Threatened Flora Translocation Sites**" to inform local government, agencies and the general public, which will reduce the risk of accidental damage occurring in future.

6 References

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Appendix 1: Photos Translocated Threatened Flora

Slender Marsdenia (*Marsdenia longiloba*)

Plate 1: Recipient Site 8a, plant no. 9, growing on wire tree guard, 6 leaves yellow-green, stem dying back.

Plate 2: Recipient Site 8a, plant no. 13, tall, healthy stem 3.2 m in height.

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Slender Marsdenia (*Marsdenia longiloba*)

Plate 3: Top left. Recipient Site 8c, plant no. 12, flowering.

Plate 4: Top right. Recipient Site 8c, plant no. 20, tall plant, many leaves, in forest mid-stratum, flowering.

Plate 5: Bottom left. Recipient Site 8c, no. 21 growing out of top of cage.

Plate 6: Bottom right. Recipient Site 8c, small plant 10 cm hjgh.

Slender Marsdenia (*Marsdenia longiloba*)

Plate 7: Top left. Recipient Site 7b no. 3, healthy, tall.

Plate 8: Top right. Recipient Site 7b no. 32, small plant 20 cm high, healthy.

Plate 9: Bottom left. Recipient Site 7b, view of habitat showing shady understorey with dense ground layer of Gristle Fern (*Blechnum cartilagineum*).

Slender Marsdenia (*Marsdenia longiloba*)

Plates 10 and 11: Recipient Site 5a. Top left plant no. 11, healthy tall. Top right plant no. 2, a small shoot. Bottom left plant no. 1, tall with few leaves. Bottom right plant no. 13, small plant with two leaves after eight years (this may be a recent shoot, but the plant hasn't grown any higher in eight years).

Slender Marsdenia (*Marsdenia longiloba*)

Plates 12 and 13: Recipient Site 5b. Approximately half the Marsdenia's translocated to this site turned out to be Large-flowered Marsdenia (*M. liisae*), a rare species, but not listed as threatened. It has larger leaves than *M. longiloba*. Three photos are *M. liisae*, bottom right is *M. longiloba*, plant no. 14.

Slender Marsdenia (*Marsdenia longiloba*)

Plates 14 to 16: Recipient site 3.

Top left – plant no. 2 about 5 metres high with the assistance of a dead sapling placed for it it to climb up into young trees.

Top right – plant no. 4, stem has grown out of top of cage, a previous stem now dead is hanging down on the right.(not a stem oscillation as it did not die back to the ground and reshoot).

Bottom left – this dumped car and other rubbish have been removed, but there is no sign identifying the site as a Threatened Flora Translocation Area, increasing the risk of this happening again.

Slender Marsdenia (*Marsdenia longiloba*)

Plate 17 and 18: Recipient Site 1. Left - plant no. 19 about 80 cm high. Right - plant no. 14 consisting of two small shoots that shot from roots underground in the last 12 months.

Rusty Plum (*Niemeyera whitei*)

Plates 19 to 21: Left – transplanted Rusty Plum after eight years has regrown from stump of bare rooted tree.

Top right – seedling recruited from one of the transplanted trees two years ago, still surviving, growing very slowly.

Bottom right – transplanted Rusty Plum, multiple coppice stems have shot from a stump about 0.7 m high

Rusty Plum (*Niemeyera whitei*)

22and 23: Recipient Site 7a. Rusty Plum translocated by direct seeding locally collected seed into protective wire mesh cylinders. Threes seeds were placed in each cylinder. After five years, two seedlings survive in one cylinder and one in the other. The seedlings are about 25 cm high and healthy, but slow growing. .

Large-flowered Spider Orchid (*Dendrobium melaleucaphyllum*)

Plate 24: Translocated Spider Orchid (*Dendrobium melaleucaphyllum*) in Recipient Site 7b. The clump of orchid pseudobulbs was moved attached to the small paperbark branch it was growing on and tied onto the tree trunk behind. The number of pseudobulbs or orchid stems has decreased by half since being moved, but remaining pseudbulbs are still in fair condition. The pseudobulbs have flowered in spring every year since being moved (as indicated by dried up flower spikes) but no seed pods formed, probably due to absence of an insect pollinator. Two orchid clumps were translocated, the second with fewer pseudobulbs than this one.

Floyds Grass (*Alexfloydia repens*)

Plates 25 to 27: Floyds Grass Recipient Site 9a

Top – southeast end of Recipient Site 9a with dense *Ottochloa gracillima* (a native mat forming grass) suppressing Floyds Grass

Middle – close-up of photo above showing *Ottochloa gracillima*. This is a native species.

Bottom – close-up of some Floyds Grass which has a flattened stem and arching, blunt tipped leaf blades. Ottochloa is in the bottom left bottom corner of this photo and has more pointed, straight leaf blades.

Floyds Grass (*Alexfloydia repens*)

Plate 28: Recipient Site 9a. Another plant displacing Floyds Grass since last year is the native ground fern *Hypolepis muelleri* (Harsh Ground Fern), which overops and smothers Floyds Grass.

Plate 29: Recipient Site 9a.

Floyds Grass tries to escape smothering Ottochloa and Harsh Ground Fern by using the stems of small woody plants for support to climb above them, seen here.

Floyds Grass (*Alexfloydia repens*)

Plate 30 and 31: Recipient Site 9b

Top – After weeding Site 9b has a low cover-abundance of exotic Broad-leaved Paspalum but small amounts of remaining Floyd Grass showslittle response.

Bottom – Site 9b, one of the larger, original patches of Floyds Grass. The grass appears stunted and discoloured, possibly due to residual effect of selective herbicide treatment to control Broad-leave Paspalum

APPENDIX 2:

PHOTOS OF IN SITU THREATENED FLORA, DECEMBER 2022

Maundia (*Maundia triglochinoides*) (in situ)

Plate 32: Maundia in-situ site on Nambucca floodplain next to highway at Macksville, Maundia regrew rapidly after the drought ended in early 2020.

Plates 33 and 34: Left - Maundia gowing in open paperbark swamp, sprayed grass on fauna fence and highway on right hand side. Right – spike of Maundia seed capsules ripening December 2022.

Slender Marsdenia (*Marsdenia longiloba*) (in situ)

Plates 35 and 36: Slender Marsdenia no. 132 off Old Coast Road next to the highway.

This small patch of stems has maintained similar height for eight years, The plant in the photo to the right grew about 1.5 m high then died back to the ground. The small plant above had grown where the previous stem had died back so is probably from the same plant's root system.

These stem dynamics are similar to those observed in the translocated plants.

Large-flowered Spider Orchid (*Dendrobium melaleucaphyllum*) (in situ)

Plates 37 to 39: Top left – in situ orchid clump growing low down on a *Melaleuca stypheloides* trunk, the same situation as the translocated clump above.

Top right – small orchid recruits growing on the trunk below the main clump above. Unless these are vegetative shoots from the orchid's roots on the tree bark, they must be seedlings, indicating a pollinator was present during flowering and a pod formed. As no pods have been recorded in eight years, the seed event was probably 10 years ago or more, indicating the seedlings grow very slowly.

Bottom right – pseudobulbs heavily damage by grazing insects or slugs, similar to the transplanted plants.

Rusty Plum (*Niemeyera whitei*) (in situ)

Plate 40: In situ Rusty Plum growing close to a turpentine with stringy bark behind, near Recipient Site 1

Koala Bells (*Artamema fimbriata*) (in situ)

Plates 41 and 42. In situ Koala Bells growing on small creek bank next to Old Coast Rd.

APPENDIX 3: PHOTOS OF SLENDER MARSDENIA AND WOOLLS' TYLOPHORA HABITAT CONDITION MONITORING PLOTS, NOVEMBER 2022

Plate 43: Habitat Condition Plot No. 7. Habitat in good condition, no exotic plants present.

Plate 45 and 46: Habitat Condition Plots No. 5 and 6. Habitat in good condition, healthy native regrowth on forest edge, few exotics, minor Lantana.

Plates 47 and 48: Habitat Condition Plot No.10. Habitat in good condition, healthy native regrowth on forest edge, no exotics inside forest, outside forest on cleared edge minor exotic grasses and weeds.

Plates 49 and 50: Habitat Condition Plot No.9. Habitat in good condition, healthy native regrowth on forest edge, no exotics inside forest.